Autecological life cycles and survivorship of *Mirabilis jalapa* L. and *Ruellia tuberosa* L. studies under varying soil moisture

ABSTRACT

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ABSTRACT

In the present work autecology including life cycle of two invasive plants namely *Mirabilis jalapa* and *Ruellia tuberosa* has been studied at selected invaded sites to workout adaptations and evolved morpho-physiological changes. *Mirabilis jalapa* (Nyctaginaceae) and *Ruellia tuberosa* (Acanthaceae) are garden escapes. The changes in the autecology and life cycles of both the selected plants growing wild were compared with pot grown plants. The community structure of invaded sites has been compared with the community structure of non-invaded sites in the same selected field. The study also includes screening of invasive traits of both the species and invasibility of the selected field or ecosystem. The community structure of the invaded sites was studied to workout relative impact of their invasion. Most of the plants after escape from cultivated to wild environment face moisture constraints besides other community attribute. The pot studies were conducted to workout growth variations in both the selected species with special reference to water stress. Besides these, the effect of varying light regimes and impact of root exudates of selected native species of the invaded community on the growth of both the species was also studied and compared to work out their response and adaptability.

The present studies were conducted in an agriculture field deserted for about 10 years. The selected field (6.97 hectares) is a fertile land and had been under cultivation until the Aligarh Muslim University acquired it in 1997. The field stretches to about 410 m in length and 170 m in width. The rain water continued to drain through the deserted and ruined water channels of the field and increased the soil moisture around it. The acquired area was enclosed by boundary walls and barbed wire fencing. The land after acquiring remained free from all human activities by the court orders. Thus the entire

field thus remained open for free invasion of native and invasive plants growing wild or cultivated around these. In the whole area 33 woody and herbaceous species have since invaded and established. At the time of acquiring the field, few trees of *Mangifera indica* and *Dalbergia sissoo* were already present. Among wild plants, *Mirabilis jalapa* and *Ruellia tuberosa* were the invasive species besides *Parthenium hysterophorus*. The invasibility of *Parthenium* sp. in various ecosystems has been extensively studied in India since 1960's. The invasibility of *Mirabilis jalapa* and *Ruellia tuberosa* has not been worked out thoroughly with reference to soil moisture and other factors. Moreover, the invasive traits of both the selected species and characteristics of invasible field are also not well known.

The selected field had patches of micro-climatic variations (soil moisture and shade). During survey of the selected field *Mirabilis jalapa* was found growing around the ruined water channels having relatively higher soil moisture. The patch was selected as Site 1 and two other patches of community with *Ruellia tuberosa* were selected as Sites 2 and 3. A patch of non-invaded site in the same field was also selected as Site 4. The seeds of both the species were collected from an adjoining field where these species were being cultivated as ornamentals. The seed of cultivated populations were used for pot studies. The population of selected plants growing in the selected field appeared to be the escapes of the population under cultivation. Thus some traits of cultivated and wild plants were compared to find out adapted growth variations of both the species.

In the selected field, *Mirabilis jalapa* germinates in the month of January. But in pots seeds germinated in the month of February. The *Ruellia tuberosa* germinates in the month of April at both the selected sites (2 and 3) but few seeds unusually germinated in the month of July as well. The later germinated seedlings of *Ruellia tuberosa* were short lived.

The studies were conducted at monthly intervals. The comparative account of the data show that the plant height and leaf number of *Mirabilis jalapa* was larger in the field as compared to those grown in pots. The plant height, leaf number, total leaf area and leaf size of *Ruellia tuberosa* decreased at invaded sites as compared to plants grown in pot. The relative water content and chlorophyll content in the leaves of both the selected plants (field or pot grown) had no statistical difference. The stomata number on adaxial and abaxial surfaces of leaf of *Ruellia tuberosa* reduced in the field individuals as compared to the individuals of pot maintained with adequate soil moisture. But, *Mirabilis jalapa* developed stomata on the adaxial surface at Site 1 which were otherwise absent in pot individuals. The total amount of tissues per unit leaf area increased in *Mirabilis jalapa* at Site 1. The above ground biomass, floral bud number, fruit number, average seed output and reproductive capacity also increased in *Mirabilis jalapa* at Site 1 and decreased in *Ruellia tuberosa* (at Site 2 and 3).

Effect of Variable Moisture

The pot studies with variable soil moisture showed that the plant height, leaf number, leaf area expansion, chlorophyll content reduced in both the species at low moisture content. But stomata number increased as low soil moisture in pots. The above ground biomass, floral buds, flowers and fruits per plants as well as average seed output reduced in both the species at low moisture content indicating that low moisture content limits both vegetative and reproductive growth of both the species. But, even then *Mirabilis jalapa* had vigorous growth in the field.

The shade increased plant height, leaf area expansion rate, stomata number in *Mirabilis jalapa*, but total leaf tissue area, above ground biomass and reproductive parameters decreased. The root exudates of three component species at Site 1 did not affect any vegetative or reproductive growth parameters of *Mirabilis jalapa* when treated under open light with adequate moisture.

Ruellia tuberosa appeared to be more sensitive to moisture content and light as compared to *Mirabilis jalapa*. The root exudates of component native species did not affect *Ruellia tuberosa*. The low moisture reduced plant height, leaf number, leaf area expansion rate, chlorophyll content, above ground biomass, floral buds, flowers, fruits and average seed output. The shade also reduced plant height, leaf number, leaf area expansion rate, stomata number, total leaf tissue area, above ground biomass and other reproductive parameters.

The soil analysis revealed that high nutrient content and organic matter in the field increased the invasibility of selected sites for *Mirabilis jalapa*. Despite low moisture in the field (as compared to pots) *Mirabilis jalapa* had better growth. The adaptability of fruit setting, average seed output, reproductive capacity, floral bud setting, above ground biomass, shorter reproductive life span in field in accordance with favorable climatic variations were the important invasive characteristics of *Mirabilis jalapa*. Better growth behavior in field despite moisture stress indicated that tuberous tap roots of *Mirabilis jalapa* occupied a different rhizosphere niche. The plant height of *Ruellia tuberosa* at Sites 2 and 3 reduced in comparison to pot cultivated plants. The moisture played important role in reproductive performance of *Ruellia tuberosa* at two sites, as was also evident from the pot experiments on *Ruellia tuberosa* with variable moisture.

On a comparison of the life cycle, it appeared that *Mirabilis jalapa* strategically had single and shorter but most effective reproductive phase at Site 1 in comparison to pot. In *Ruellia tuberosa* the total span of life cycle and span of reproductive phase reduced in the field to adapt with the available growth attributes. Moisture variation at Sites 2 and 3 directly affected the span of reproductive phase of *Ruellia tuberosa*. The span of life cycle of *Ruellia tuberosa* was of 12 months in pots maintained with adequate moisture, but 11 months at Site 3 and 10 months at Site 2. The span of life cycle was in conformity with the soil moisture. The variation in reproductive parameters was also influenced by shade and low moisture. The vegetative and reproductive growth parameters of *Ruellia tuberosa* reduced in shade as well. Therefore, the reduction in plant height of *Ruellia tuberosa* may have been jointly influenced by reduced luminance and moisture content at Sites 2 and 3. From field and pot studies, it is evident that *Mirabilis jalapa* had relatively wider ecological amplitude than *Ruellia tuberosa* and therefore former appears to be a long persisting invasive species than the later.

Invasive Characteristics of Both the Species

The invasive characteristics of both the selected species as worked out in the present study are listed against each species.

Mirabilis jalapa : Good adaptability with component native species, adaptability to low moisture, rapid and vigorous growth immediately after germination, reduced flowering span, high reproductive potential, high survivorship under environmental adversities in field, ability to explore available nutrients to its maximum benefit, wide ecological amplitude (for water stress) and ability of invasional meltdown through *Parthenium hysterophorus*.

Ruellia tuberosa : Moderate adaptability with native component species, rapid growth. short flowering time, vigorous vegetative and reproductive growth in field conditions, decreased plant size, high reproductive potential, multiseeded fruits, high survivorship under in field, moderately wide ecological amplitude for soil moisture and shade.

Invasibility of Ecosystem

The comparison of the characteristics of the selected sites and pots showed that high nutrient content in the selected field, just adequate moisture and open light made the Site 1 of the ecosystem highly invasible for *Mirabilis jalapa*. High nutrients (NPK), shade and relatively low moisture proved to be cause of invasion of *Ruellia tuberosa* at Sites 2 and 3. All the selected sites remained undisturbed for long and therefore, the invasion of both the selected species was not found related with the disturbance regime in contrary to earlier findings. The invasion of *Parthenium hysterophorus* caused invasion meltdown and made the Site 1 invasible for *Mirabilis jalapa*. The root exudates of selected native species did not affect the growth and establishment of both the selected invasive species at their respective invaded sites. The low moisture at Site 2 and 3 may have checked the invasion of *Ruellia tuberosa* but the adaptability of species to reduce its life cycle under limited water stress kept the Sites 2 and 3 invasible.

It is inferred from the findings that besides possession of invasive characteristics, the invasibility of ecosystem is equally imported for plant invasions. The moisture, nutrient availability and adequate light availability are important for plant invasion in a given ecosystem besides the invasive characteristics. The invasion meltdown or positive relationship of a invasive species with another alien species as 'enemy of enemy is a friend' may be taken as a joint characteristics (as invasive traits of the species and invasibility of such ecosystems).

Table C. Impact of varying factors on the growth of ***Ruellia tuberosa*** treated at varying growth stages (30 and 60 days after germination) and studied up to 35 days (summary of Tables 29 to 61 and 77 to 93).

S. No.	Parameters	Stages	Responses for varying factors		
			Moisture	**Light**	**Root exudate**
1.	Plant height (cm)	30DAG	Reduced at W_3, W_4 and W_5	Reduced in shade	NS
		60DAG	-do-	NS	NS
2.	Leaf number per plant	30DAG	-do-	Reduced in shade	NS
		60DAG	-do-	-do-	NS
3.	Leaf area expansion per plant	30DAG	-do-	Decreased in shade	NS
		60DAG	-do-	-do-	NS
4.	Relative water content, Chlorophyll content (a, b and total)	30DAG	Reduced except Chlorophyll-b NS	NS	NS
		60DAG	Reduced except Chlorophyll-a and b NS	NS	NS
5.	Stomata number and index (adaxial surface)	30DAG	Reduced at W_3 and Increased at W_4-W_5	Decreased in shade	NS
		60DAG	-do-	-do-	NS
6.	Stomata number and index (abaxial surface)	30DAG	Reduced at W_3 and Increased at W_4-W_5	Number decreased and index increased	NS
		60DAG	-do-	-do-	NS
7.	Total leaf tissue area	30DAG	Increased at low moisture	Reduced in shade	NS
		60DAG	-do-	-do-	NS
8.	Above ground biomass	30DAG	Reduced at low moisture	Reduced in shade	NS
		60DAG	NS	NS	NS
9.	Number of floral buds, flowers and fruits	30DAG	-do-	Decreased in partial light and shade	NS
		60DAG	-do-	-do-	NS
10.	Average seed output	60DAG	-do-	-do-	NS

DAG–Days after germination

Table B. Impact of varying factors on the growth of ***Mirabilis jalapa*** treated at varying growth stages (30 and 60 days after germination) and studied up to 35 days (summary of Tables 29 to 76).

S. No.	Parameters	Stages	Responses for varying factors		
			Moisture	**Light**	**Root exudate**
1.	Plant height (cm)	30DAG	Reduced at W_3, W_4 and W_5	Increased in shade	NS
		60DAG	-do-	NS	NS
2.	Leaf number per plant	30DAG	-do-	Reduced in shade	NS
		60DAG	-do-	-do-	NS
3.	Leaf area expansion per plant	30DAG	-do-	Increased in shade	NS
		60DAG	-do-	-do-	NS
4.	Relative water content, Chlorophyll content (a, b and total)	30DAG	-do-	NS	NS
		60DAG	-do-	NS	NS
5.	Stomata number and index (adaxial surface)	30DAG	-	Increased in shade	NS
		60DAG	-	-do-	NS
6.	Stomata number and index (abaxial surface)	30DAG	Reduced at W_3 and Increased at W_4-W_5	Number increased and index decreased	NS
		60DAG	-do-	-do-	NS
7.	Total leaf tissue area	30DAG	Increased at low moisture	Reduced in shade	NS
		60DAG	-do-	-do-	NS
8.	Above ground biomass	30DAG	Reduced at W_3, W_4 and W_5	Reduced in shade	NS
		60DAG	-do-	NS	NS
9.	Number of floral buds, flowers and fruits	30DAG	-do-	Decreased in partial light and shade	NS
		60DAG	-do-	-do-	NS
10.	Average seed output	60DAG	-do-	-do-	NS

DAG–Days after germination

Table A. Changes in the growth of ***Mirabilis jalapa*** at Site **1** and ***Ruellia tuberosa*** at Site **2** and **3** in comparison to plant growth in pots (summary of Tables 24 to 28).

S. No.	**Parameters**	**Site 1**	**Site 2**	**Site 3**
1.	Germination	January (February in pots)	April and unusual in July	April and unusual in July
2.	Plant height	Increased	Decreased	Decreased
3.	Leaf number	-do-	-do-	-do-
4.	Leaf area	Decreased	-do-	-do-
5.	Total leaf area	-do-	-do-	-do-
6.	Relative water content, Chlorophyll content (a, b and total)	No response chlorophyll content decreased (June and July)	No response chlorophyll content decreased	No response chlorophyll content decreased
7.	Stomata number and index (adaxial surface)	Developed from January to June (Absent in pots)	Decreased	Marginal decreased
8.	Stomata number and index (abaxial surface)	Decreased	-do-	Decreased
9.	Total leaf tissue area	Increased	Increased	Decreased
10.	Above ground biomass	-do-	Decreased	Decreased
11.	Floral bud number	-do-	-do-	-do-
12.	Flower number	Almost same	-do-	-do-
13.	Fruit number	Increased	-do-	-do-
14.	Average seed output	-do-	Decreased	Marginal decreased

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Dedicated To

My Beloved Father

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CERTIFICATE

This is to certify that the **Ph.D. thesis** entitled **"Autecological life cycle and survivorship of *Mirabilis jalapa* L. and *Ruellia tuberosa* L. studies under varying soil moisture"** embodies original and bonafied work carried out under my supervision by **Ms. Jyoti Varshney** and that no part of this thesis has been submitted for any other degree or diploma.

(Fareed Ahmad Khan)

Supervisor of Research

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CONTENTS

Introduction

INTRODUCTION

Autecological life cycle and survivorship reflects the adaptive and invasive traits of plants under varying set of environment. The invasibility of plants varies with the species and largely depends on the invasiveness of the ecosystem. Autecological life cycles may be helpful in understanding broader range of adaptation, role and behaviour of any invasive species in its newly invaded ecosystem. Anthropogenic changes in the distribution of the plant species from one part of the globe to another is a serious threat to earth's biodiversity and ecosystem stability.

Invasive species have their own dispersal mechanism and often colonize a new area having a conducive environment for their establishment and growth. Most plant species have their own specific ecological amplitudes, niches and associations. When such plants are dislocated from one coevolved relationship, they may undergo ecological transformations. But some cosmopolitan members of Asteraceae and Poaceae have wider ecological amplitudes and broader plant association range. Such species do not necessarily undergo any major course of ecological transformations. The cultivated plants usually have narrow ecological amplitude. Some cultivated species, during the course of cultivation over a long period, may get adapted to the area. Such species when escape in wild, may transform themselves and co-establish with native wild plants growing around there. The ecosystems with high invasiveness may remain open for the plant invasion. Such ecosystems may have several invasive species with or without major or minor change in the native diversity at autotrophic level.

Invasions of alien plants in native communities have often occurred around the world. The invasive species are geographically displaced or dislocated from their coevolved biota to a less-familiar biota. Some of the invasive species may have far reaching impacts on role of native constituents of ecosystem in question and may prove to be a keystone species.

The term 'invasive plant' denotes "Plants which escape cultivation and gets established on a natural area and start expanding and reproducing on their own" (Hallett 2006). This definition is focused on plant escape from cultivated to nearby natural area. A broader definition covering escape and geographically displaced species has also been proposed as "Invasive plants are a subset of naturalized plants that produce reproductive offspring often in a very large number at considerable distances from the parent plants and thus have the potentials to spread over a large area" (Richardson *et al.* 2000b, Pyšek *et al.* 2004b). Recently the term 'invasive species' has been defined as "A species outside of its native range whose introduction and/or spread threatens biodiversity" (Anonymous 2008).

The geographical origin of plants influences their invasiveness in new area (Reichard 2001, Lloret *et al.* 2004). The species from a large continent may more easily invade a new habitat having similar climate as compared to species from a small continent to a new habitat with a different climate (Mihulka and Pyšek 2001). Plants generally invade the area of high human activities such as- garden boundaries, common dumping sites, old home sites, road side ditches, disturbance area and fire lines. The invasive plants (including herbs, shrubs and trees) have certain common specific biological characteristics that predispose them toward invasiveness. Adaptability of invasive species to thrive in a vast set of habitats (wider ecological amplitude), their capability to tolerate variable growth conditions (viz. moisture, light and temperature etc), faster growth rate (ability to outcompete neighbouring plants) and effective dispersibility by means of fruit, spores or vegetative parts are some of the ways of plant invasions (Staples *et al.* 2000, Pan *et al.* 2007, Jia *et al.* 2009). In fact, these well evolved characteristics are the part of plant's invasive strength.

The plant invasion has become a significant threat to biodiversity, environment and economics both globally and locally (Mack *et al.* 2000, Pimentel *et al.* 2000, Liu *et al.* 2001, Mitchell and Power 2003, Wixted and McGraw 2009). It is critical to analyze the invasive ability of plants so that likely invasive species can be screened (Goodwin *et al.* 1999) for control strategies. Two most urgent tasks of ecologists are to understand the factors influencing invasive success of plants and develop means to predict plant invasions (Heger and Trepl 2003). Unfortunately, there is no consensus on invasion mechanisms and predictive models (Alpert *et al.* 2000, Milbau *et al.* 2003).

In contrary to a recent theory, it is proposed that the plant invasion is not determined by their life history traits or nature (invasibility) of the ecosystem (Hallett 2006). To establish or overrule the theory, it is necessary to study the life history traits of invading species in and outside the invaded ecosystem along with the behavior of invasive species with or without interaction with the other components of the ecosystem.

Life cycle of a plant is greatly influenced by a number of environmental factors. In nature, species never grow singly. Usually, several plant species together from a community with a definite pattern of appearance. Study of all stages of life cycle of a particular species in nature, in association with other species of the locality and completely bathed in above and belowground environment is the core of autecology.

Widely distributed wild plants occupy a variety of habitats and their life cycles differ accordingly. MacArthur and Wilson (1967) developed the ecological concept of stability of plants in relation to their two well evolved survival strategies or lines of selection for using variety of habitats and environment. The 'r' selection species (mostly annuals) are density independent with a very high reproductive rate. While 'k' selection species are perennials with low reproductive rates and density dependent close to the carrying capacity of their habitat. The 'r' selection plants tend to occupy a new habitat rapidly. Explosive reproduction rates are usually followed by a rapid decline in the size of the plants with the onset of competition. The length of life cycle of 'r' selection species is typically short. Thus the plants with larger fluctuations in population size are common colonizers. The species with 'k' strategies use resources efficiently and reproduce slowly (MacArthur and Wilson 1967).

In the present work, life cycles of two selected studies have been studied with emphasis on autecological parameters. Besides these some community factors of invaded ecosystem have also been studied and compared with non-invaded community. The soil moisture besides some other factors results into microclimatic variations in a vast area of plant habitat. The microclimatic variations lead to patchiness in the community. Each patch differs in dominant and co-dominant species. The micro-climatic variations may eliminate some species. The niches and space of eliminated native species may be made available to other native species or often to alien species for invasion. In the selected invaded field (described later), the soil moisture was noted to be variable at varying sites. The present study has been conducted with reference to soil moisture.

Soil moisture is an important growth factor and determines local diversity. The plant responses to variation in soil moisture are quite diverse (Strain and Thomas 1995). Aligarh is characterized with the semi-arid zone climate of India. In semi-arid regions, soil water resulting from episodic seasonal rainfall (last week of June to mid September) evaporates rapidly. Plants following periods of soil water deficit may not be benefited from such water additions if near surface roots fail to resume water uptake rapidly. Numerous factors may lead to soil moisture related drought stress including restricted soil compaction. Nutrient availability, uptake and transport are hampered without adequate water.

The impact of water scarcity on plant growth is complex and varies between adaptive change and deleterious effects. Under field conditions, these responses can synergistically or antagonistically be modified by the superimposition of other stresses (Chaves *et al.* 2002). The invasive plants having adequate adaptability may take advantage of the stressed environment to invade the area. Besides adaptive variability in life cycles, the morpho-physiological adaptability of species at vegetative and reproductive growth stages is also very crucial. In the present work, the effect of variable water regimes has been studied at pre- and post-flowering growth stages of the selected invasive plants.

The water stress at early growth stage may lead to the onset of new metabolic and structural capabilities if mediated by altered gene expression and eventually the stressed plant may survive. This drought induced and genetically controlled adaptation helps plant in improving its functioning under such stress (Bohnert and Sheveleva 1998, Chaves *et al.* 2002). Some of these responses may be limited to the level of leaf and in some others to the whole plant. The adaptive stimulus may be generated within the leaves or any other part at some cost of growth and carbon assimilation and allocation (Chaves *et al.* 2002). The alterations in carbon allocation may be reflected in reproductive capacity (Pereira and Chaves 1993, Chaves *et al.* 2002) and/or vegetative growth. Osmotic adjustment is an important adaptive strategy of plant to survive under water stress (Kusaka *et al.* 2005). This adjustment enables physiological activity to retard down at lower moisture level throughout the period of water deficit (Turner 1997). Some of these parameters have also been studied.

Many plant species have evolved ecotypic differentiation in response to a variety of selection pressures (Peuke *et al.* 2002, Grant *et al.* 2005). The adaptive strategies of a species vary with the continent and populations of contrasting environments (Lauteri *et al.* 1997, Grant *et al.* 2005). The accounting of varying strategies of a species needs to be studied in the populations of varying continents thriving under similar set of environmental conditions (Oleksyn *et al.* 1998, Grant *et al.* 2005). The increase in leaf thickness and density in *Quercus ilex* related with the worsening of ecological conditions has been found species specific (Grossoni *et al.* 1998, Bussotti *et al.* 2000) when grow in association with *Phillyrea latifolia* (Tattani *et al.* 2001) and *Myrtus communis* (Mendes *et al.* 2001). But, this change in *Q. ilex* has not been recorded in the individuals growing with other sclerophyllous species such as *Arbutus unedo* and *Pistacia lentiscus* (Gravano *et al.* 2000).

Plant considered varying organs for responses to stress at varying stages of development (Ozkan *et al.* 1999). The response of whole plant to stress at vegetative stage (pre-flowering) may have resulted from the individual response of leaf (Delpérée *et al.* 2003).Plant on reaching maturity reacted differently when subjected to water stress for the entire growth cycle as compared with the plants initially grown with adequate water and subjected to drought only after reaching full size (post-vegetative). Water stress decreased cell membrane (Cellier *et al.* 1998, Deshmukh *et al.* 2000, Al-Hamdani and Barger 2003).These feasible adaptive features of the selected invasive species including changes in proportions of leaf tissues have also been studied.

Plants have three adaptive strategies to soil moisture deficiency as escape, avoidance and tolerance (McCue and Hanson 1990). Soil moisture is the main limiting factor for plant growth and survival (Erdei and Taleisnik 1993, Kefei and Zhang 1997, Puppala *et al.* 1997, Ghassemi-Golezani *et al.* 1998, Egert and Tevini 2002, Singh and Singh 2003, Ashraf *et al.* 2004, Nadia *et al.* 2004, Singh and Singh 2006). In response to variable water regimes, plants develop morphological, physiological and anatomical changes (Kefei and Zhang 1997, Egert and Tevini 2002, Singh and Singh 2003, Ashraf *et al.* 2004, Singh and Singh 2006) like reductions in stem height (Islam 1999, Islam and Gretzmacher 2000, Rahman *et al.* 2002, Lauer 2003), number of leaves (Belaygue *et al.* 1996, Lefi *et al.* 2004, Slama *et al.* 2006), leaf area (Belaygue *et al.* 1996, Abernethy *et al.* 1998, Lefi *et al.* 2004,Yin *et al.* 2005, Slama *et al.* 2006), abundance of stomata (Yin *et al.* 2005, Fraser *et al.* 2009), trichomes (Abernethy *et al.* 1998) or may have excess leaf wax, thick cuticle and compact palisade. Adaptations, promote water homeostasis either by restricting water loss from the plant body or by increasing water absorption to compensate water loss in transpiration.

The delayed flowering was recorded when plant faced stress at vegetative stage. But, water stress at reproductive stage induced early maturity and abortion of floral organs in soybean (Westgate and Peterson 1993) and immature ovules in maize (Westgate 1994). Moderate water stress reduced floral buds (Garcia *et al.* 2004) and induced their abortion in soybean (Westgate and Peterson 1993) and pea (Ney *et al.* 1994). The moderate water stress has also been noted to reduce flower production (Barrios *et al.* 2005), fruit setting (Board *et al.* 1990) and seed output in wheat (Midmor *et al.* 1984), soybean (Jiang and Egli 1995, Vega *et al.* 2001), maize and sunflower (Vega *et al.* 2001). The water stress at post-reproductive stage may, therefore, affect invasibility of species unless the species possess or develop some adaptability to overcome the stress. The alien species with adequate water stress adaptability may take advantage in establishing themselves over stressed native species.

In planes of Northern India, there are three main climatic regions: the summer, monsoon and winter seasons. The periods of summer, monsoon and winter lasts from March to June, July to September and October to February, respectively. The summer and winters may have sporadic and short spells of rain. The years with deficient or excessive rainfall during monsoon are frequent. The plants growing in wild have to face all such adversities of the environment. Some invasive plants got colonized and became naturalized in the region with some variations in their life cycles and expectedly through some adaptations in their survivorship strategy. These invasions have displaced several native species (Vitousek *et al.* 1996). The invading plants can alter the growth, density, frequency, life cycles, composition of native species and thereby the ecosystem structure and properties (Nutrient cycling, productivity, hydrology etc). Upon plant invasion the rules of co-existence of component organisms of the ecosystem gets changed (Vitousek 1990). Hence, plant invasion pose a serious threat to global biodiversity and economy worldwide (Vitousek *et al.* 1996, Mack *et al.* 2000, D'Antonio *et al.* 2001, Ding *et al.* 2006). Invading plants may initiate the extinction of some or most of the native plants and thereby reduce the community richness. The characteristics of a habitat play major roles in determining the success or failure of a potential invader (Newsome and Noble 1986, Noble 1989, Chytrý *et al.* 2009, Milbau *et al.* 2009). The success and failure of evolved adaptive characteristics of invaded species is reflected in the community characteristics. Some of the community indices have also been studied as part of the site characteristics and outcome of invasion of the selected species.

As with all plants, invasive plants are also limited by the stresses of environments around them. If ecological amplitude of invasive species for water and light are known then the areas prone to invaders may be predicted (Merchant 1998). Some evidences support the view that invasive plants are less tolerant to water stress than natives (Alpert *et al.* 2000, Schumacher *et al.* 2003). Furthermore, understanding of ecological constraints to the distribution of invasive plants would help scientists create new and hopefully better method of control (Mack 1996).

Hence, evaluation of invasive plants through autecological studies, their adaptability and survival strategy under varying soil moisture and other factors is of a great importance. The present study has been conducted on two selected invasive species namely, *Mirabilis jalapa* and *Ruellia tuberosa*. The *Mirabilis jalapa* having the therapeutic uses is often cultivated. *Ruellia tuberosa* is also cultivated as ornamental and also used as antehelmentic against joint pains and muscle strain.

In the present work, variations in the morphology, physiology, biochemical processes and life cycles have been studied with special reference to varying soil moisture. The impact of light and root exudates of some native species on the growth of the selected species has also been worked out. The overall growth response of both the species to these variables (mainly water besides light and root exudates) has been studied to compare the growth, survival and life cycles of pot cultivated individuals with those invaded in the field. The major objectives of the studies were as follows-

1). To find out the effect of varying soil moisture on the morphological adaptable invasive traits of selected species.

2). To workout growth response of selected invasive species under cultivation (in pots) and field conditions (as invader).

3). To workout adaptive changes in the life cycle of *Mirabilis jalapa* and *Ruellia tuberosa* in response to varying soil moisture and some other habitat/community attributes viz., light and root exudates of native species.

4). To workout evolved adaptive morpho-physiological changes in selected species making them to invade and establish in a new area.

5). To study the invisibility factor of invaded community.

Literature Review

LITERATURE REVIEW

Autecology and Survivorship

Exhaustive studies on autecological life history of plants may be helpful in its revegetation (West 1967). The autecological studies may, therefore, reveal invasibility of a species. Each stage of life cycle of a plant is greatly influenced by a number of environment factors (stress and disturbance). The stress and disturbance factors control the establishment and development of native and invasive plants in deferent ecosystems. The fluctuations in environmental factors increase the invasibility of ecosystem by invading plants.

Plants have evolved two major strategies of survival as *k*- and *r*-selection (MacArthur and Wilson 1967). The species with *r*-strategy have high reproduction to ensure maximum chances of growth (r) or reappearance in the invaded ecosystem. The *k*-strategy species allocate nutrient resources to strengthen the structure and functioning of the organism (maximization of *k*- which is the carrying capacity of a mature ecosystem for the organism). Grime (1979) proposed a model based on three primary ecological strategies viz., C-competitive, S-stress and R-ruderal. Garbey *et al.* (2004) studied the influence of disturbance or stress on the plant traits in *Ranunculus peltatus* growing in soft water and found that this plant in nutrient poor but undisturbed sites in upstream adopted S-strategy by reducing its size and sexual reproduction. But the species in nutrient rich undisturbed sites had long branching shoots showing to C-strategy. Whereas, individuals of *Ranunculus peltatus* under partially shaded (unstressed) disturbed sites were small and produced many flowers expressing R-strategy and thus. this species adopted variable strategies for its survival showing adaptation of morphological traits to physical environment more than to chemical stress (Trémolières 2004).

Plant Invasion

The geographical origin of invasive plant may influence their invasiveness in new area (Reichard 2001, Lloret *et al.* 2004, Chytrý *et al.* 2009, Milbau *et al.* 2009). In addition, species from large continent may more easily invade a new habitat where the climate is similar to their geographical origin, as compared to species from a small continent and in new habitat having a different climate (Sax and Brown 2000, Mihulka and Pyšek 2001). China is the third largest country in the world in terms of territory and possesses mega-diversity of plant species with numerous invasive alien plant species (Xie *et al.* 2000, Liu *et al.* 2006). Some plant communities lead to the plant invasions themselves (Vitousek *et al.* 1996, Levine and D'Antonio 1999, Smith and Knapp 1999, Alpert *et al.* 2000, Davis *et al.* 2000, Levine 2000, Milbau and Nijs 2004). Controversies exist over the plant characteristics (e.g. life history, taxonomic groups or geographic origin) which may contribute to invasion processes.

In India, an obnoxious weed (*Parthenium hysterophorus*) was accidently introduced during 1950s feasibly through wheat import from Mexico. The weed first invaded in Pune (western India) in 1956 and spread rapidly all over the country mainly in disturbed habitats, grazing lands and crop fields. About 5 million hectare of land has been invaded by *Parthenium* species in India (Kohli and Rani 1994, Angiras and Saini 1997, Mukhopadhyay 1997). For invasion, *P. hysterophorus* adapted two major invasive traits namely, allelopathy and high reproductive capacity (Pandey and Dubey 1989).

Invasive plants escape cultivation and act as agriculture pests. These escapes may displace native plant species and alter ecosystem process. In any ecosystem, invasive plants posed potent threats to native species, natural communities and ecosystem process (Luken and Thieret 1997). Hannah *et al.* (1994) explained that roughly 52% of the earth's total terrestrial area remains undisturbed by humans. But, nearly 75% of the human settlement area is disturbed to some degree. The human settlement areas are most vulnerable to plant invasion. The other area vulnerable to plant invasions include roadside, trodden paths grasslands (especially when overgrazed), riparian habitats, waterways, sand dunes, old fields, post-harvest forest and some forests supplied with high light (Baker 1986). A biological invasion is considered to be a normal event (Lodge 1993). Plant invasion has become a significant threat to biodiversity, environment and economics both globally and locally (Mills *et al.* 1994a, Hobbs and Humphries 1995, Rejmánek and Richardson 1996, Vitousek *et al.* 1996, Vitousek *et al.* 1997, Lodge *et al.* 1998, Wilcove *et al.* 1998, Mack *et al.* 2000, Pimentel *et al.* 2000, Liu *et al.* 2001, Callaway 2002, Levine *et al.* 2003, Mitchell and Power 2003, Thomson 2005, Liu *et al.* 2006, Tecco *et al.* 2006, Burt *et al.* 2007, Jia *et al.* 2009, Wixted and McGraw 2009).

Causes of Plant Invasion

Anthropogenic disturbances include the removal of plant biomass, excessive nutrient enrichment, soil disturbance and altered fire or hydrological cycles (Hobbs 1991). Disturbances by altering resource availability facilitate plant invasions (D'Antonio 1993, Thompson *et al.* 2001, Jia *et al.* 2009). The removal of live above ground biomass and plant litter affect community composition significantly (Grime 1977) because phytotoxicity and litter first influence invasion of new species and then alter the nutrient cycling (Dzwonko and Gawronski 2002), soil moisture (Facelli *et al.* 1999), temperature regulation (Vellend *et al.* 2000), light penetration (Facelli and Pickett 1991, Vellend *et al.* 2000), physical observation of germination and growth (Facelli *et al.*

1999) and competitive interactions (Tilman 1982).

Water and light mainly affect leaf traits, regulate plant growth and survival (Holmgren 2000, Sack and Grubb 2002, Sack 2004, Aranda *et al.* 2005, Quero *et al.* 2006). These two factors also determine the plants distribution on global scale. The functional response of seedlings to the combination of drought and shade involves biochemical, physiological and structural changes mainly in the leaf and often in whole plant (Holmgren 2000, Sack and Grubb 2002, Sack 2004, Aranda *et al.* 2005, Quero *et at.* 2006). The effect of light stress was stronger than water stress in some species (Baruch *et al.* 2000). Merchant (1998) found a significant decrease in total leaf surface area in two invasive brooms as light intensity increased and also noted decrease in leaf area with increasing water stress. Baruch *et al.* (2000) pointed out that partial shade increased leaf area ratio more in herbs (140%) than in woody species (68%). But water can modify the effect of light and temperature. Thus water stress or availability, in fact plays more significant role in the establishment, growth and survival of native species and invasion of alien species in any ecosystem.

Invasive plants sometimes established facilitative interactions among themselves (Simberloff and Von Holle 1999) and with native plants (Richardson *et al.* 2000a, Stachowicz 2001, Lenz and Facelli 2003). But, their facilitative interactions were not confined to any particular growth form (Cronk and Fuller 1995, Tecco *et al.* 2006). Invasibility was often related to disturbance regime, climate, level of environmental stress and several other factors (Levine and D'Antonio 1999, Smith and Knapp 1999, Alpert *et al.* 2000, Davis *et al.* 2000, Levine 2000, Milbau and Nijs 2004, Eschtruth and Battles 2009).

Invasive Characteristics

It is critical to analyze the invasive ability of plants before their introduction to a new locality (Goodwin *et al.* 1999). The factors influencing invasion success of plants have emphasized to be worked out to develop means for predicting plant invasions (Heger and Trepl 2003).

Invasion ecology varies with species invisibility, rate and mechanism of transport and movement of a species and properties of ecosystem. Probable traits favoring invasiveness of terrestrial plants include high tolerance and adaptability against environmental extremes (wide ecological amplitude), efficiencies for zero or very short dormancy period and high reproductive potential (Anonymous 2005). Lambdon *et al.* (2007) emphasized three main characteristics of invader by which they establish and flourish in any ecosystem: it may occupy the same niche as of one or more natives and successfully out compete them (Schnitzler and Muller 1998, Callaway and Aschehoug 2000, Chittka and Schürkens 2001), it may coexist with native species, each species possessing an advantage across a different part of the initial niche space (Dietz and Ullmann 1997, Cizek *et al.* 2003) or it may fill unoccupied niches either because no native has evolved into them (Vitousek 1988) or because they have been vacated following extinctions perhaps due to environmental degradation (Shea and Chesson 2002). Recently, many more invasive characteristics have been worked out (Cochard and Jackes 2005, McDowell and Radosevich 2005, Tecco *et al.* 2006, El-Keblawy and Al-Rawai 2007, Pyšek *et al.* 2007).

The invasion success has been attributed to superiority of the invasive species in terms of genome size, phenotypic plasticity, reproductive capabilities, seed dispersal mechanism, seedlings establishment and survivorship (Daehler 2003, Rejmánek *et al.*

2005, Pyšek and Richardson 2007, Hulme 2008). The invasive characteristic depends on plant size, susceptibility to herbivory and pathogens, phenology, mutualistic interaction, allelopathy and plant soil relationships (Pattison *et al.* 1998, Smith and Knapp 2001, Ridenour and Callaway 2001, Kollmann and Bañuelos 2004, Richardson 2004, Barrat-Segretain 2005, Cadotte *et al.* 2005, Orr *et al.* 2005). Besides these traits, the rapid growth (Piank 1994, Cronk and Fuller 1995, Oliver 1996, Barrilleaux and Grace 2000, Daehler 2003), short flowering phase (Kollmann and Bañuelos 2004, Richardson 2004), high reproductive potential, long distance dispersal of propagules (Perrins *et al.* 1992, Thompson *et al.* 1995, Rejmánek and Richardson 1996, Goodwin *et al.* 1999, Barrat-Segretain 2005) are also attributable to the success of plant invasion. *Prosopis juliflora* equipped with seed dormancy, germination and seed dispersal facilitated its rapid invasion in new area (Shiferaw *et al.* 2004, El-Keblawy and Al-Rawai 2005).

Successful invaders have also been suggested to have fewer enemies (predators, parasites or diseases), than native which can be major reason for success (Cornell and Hawkins 1993, Keane and Crawley 2002). Invaders may also be good competitor (Joly 2000, Vilà and Weiner 2004). The traits associated with invasive species are broad native range, short germination time, long fruiting period, large seed crops, prolonged seed viability and transport by winds or animals (Richardson and Cowling 1992, Pyšek *et al.* 1995, Rejmánek 1996, Rejmánek and Richardson 1996, Williamson and Fitter 1996, Goodwin *et al.* 1999, Rejmánek 2000, Kolar and Lodge 2001, Rejmánek *et al.* 2005, Pyšek *et al.* 2007). Invader traits can be categorized in terms of reproduction variation, environmental tolerance, allelopathy, competitive effect (Goldberg 1990, Piank 1994, Cronk and Fuller 1995, Sher and Hyatt 1999, Barrilleaux and Grace 2000).

In addition to many invasive characteristics, *Spacium sebiferum*- a multiple tolerant species withstand short duration salt water flooding, long duration freshwater flooding and extreme shading to about 5% of full sunlight (Jones and Mcleod 1990, Jones and Sharitz 1990, Conner and Askew 1993, Barrilleaux and Grace 2000). Evidences indicate that invasion first occur in areas of high soil moisture, whereas drier region are invaded at a slower rate (Helm *et al.* 1991, Kuldeep *et al.* 1993).

According to Pyšek *et al.* 2007, reproductive traits are crucial for successful invasions of plants (Rejmánek and Richardson 1996, Rejmánek *et al.* 2005) and affect the probability of their subsequent naturalization (Richardson *et al.* 2000a, Pyšek *et al.* 2004a). Invasiveness in plant species is correlated with the ability to reproduce abundantly and grow rapidly. The traits such as the sexual and vegetative reproductive ability, self fertilization, lack of seed dormancy and multi-seeded fruit help in rapid colonization of a site which is the first stage of the invasion process (Reichard and Hamilton 1997, Daehler 1998, Sakai *et al.* 2001). Fast growth rate reflects rapid acquisition and allocation of resources and also the ability of a plant to establish itself in the ecosystem (Stearns 1992). The life history traits predict trades off between high reproduction and growth rates (Stearns 1992). The trades off between reproductive growth and vegetative growth are due to competition for limited resources within an individual (Stearns 1992, McDowell and Radosevich 2005). Some species introduced in a new area tend to flower earlier and longer than in their native habitat (Wolfe *et al.* 2004, Alpert 2006).

In most of the studies specific growth parameters of a number of invasive plants have been studied with respect to growth limiting factors. In earlier studies on invasive plants mainly distribution, association and role of growth limiting factors have been emphasized (Perrins *et al.* 1992, Thompson *et al.* 1995, Burke and Grime 1996, Rejmánek and Richardson 1996, Pattison *et al.* 1998, Schnitzler and Muller 1998, Goodwin *et al.* 1999, Alpert *et al.* 2000, Callaway 2002, Callaway and Aschehoug 2000, Mack *et al.* 2000, Chittka and Schürkens 2001, Ridenour and Callaway 2001, Smith and Knapp 2001, Kollmann and Bañuelos 2004, Kohli *et al.* 2004, Anonymous 2005, Barrat-Segretain 2005, Cadotte *et al.* 2005, Orr *et al.* 2005, Lambdon *et al.* 2007).

Many invasive species including *Mirabilis jalapa* and *Ruellia tuberosa* have not been so far studied with reference to their growth pattern, life cycle and survivorship strategies. The population growth of plants with *r*-strategy is resource independent and has shorter life cycles. The population growth of plants with *k*-strategy is resource dependent and has longer life cycles. Most of herbaceous or woody herbaceous plants may be density independent while perennial plants having usually *k*-strategies are strictly density dependent. These factors may prove to be important invasive characteristics of plants. The autecological life cycle of invasive plants may significantly differ in cultivated and invaded habitats. The variations in life cycle patterns may indicate its adaptability, evolved strategy and invasive trait. Several environmental factors including soil moisture regime may induce variation in the life cycle of plant such as high rates of reproduction (through propogules and/or seeds), long seed viability (Piank 1994, Pyšek 1997, Barrilleaux and Grace 2000, Pyšek *et al.* 2003, Mandák *et al.* 2004), plant size and time of flowering (Richardson 2004), early and longer phase of flowering, fruiting and higher seed output (Rejmánek and Richardson 1996, Reichard and Hamilton 1997, Wolfe *et al.* 2004, Alpert 2006), decrease in stem height, biomass, leaf number and leaf area (Merchant 1998, Baruch *et al.* 2000).The light may also induce some of these variations (Merchant 1998, Oliveira and Souto 2002).

Ecosystem Invasibility

Plant invasion in a community depends on their invasive traits (Rejmánek and Richardson 1996, Tilman 1997, Alpert *et al.* 2000, Smith and Knapp 2001, Grotkopp *et* *al.* 2002, Prinzing *et al.* 2002) and characteristics of target community (Lonsdale 1999, Davis *et al.* 2000, Mack *et al.* 2000, Levine *et al.* 2003). The susceptibility of a community to invasion also depends on its species richness (Burke and Grime 1996, Tilman 1997, Hector *et al.* 2001), resource availability at disturbance regime (Burke and Grime 1996, Alpert *et al.* 2000, Mack *et al.* 2000) and competition between native and invader species (Maron and Vilà 2001, Miller *et al.* 2002, Barrat-Segretain 2005). The competition ability of invader and susceptibility of invasive community are related with availability of a bare ground (Burke and Grime 1996) and plant diversity (Barrat-Segretain and Elger 2004).

Large scale destruction of native species increased soil fertility and thus invasive plant had dual advantage of availability of space and resource in addition to reduced competitive resistance for invader (Burke and Grime 1996, Levin and D'Antonio 1999, Lonsdale 1999, Stohlgren *et al.* 2001, Thompson *et al.* 2001). Disturbance increased resource availability through a number of pathways including soil disturbance, unlocked nutrients stored in soil organic matter by changing soil microclimate, microbial community structure or by making new substrate available for decomposition by breaking up soil aggregate (Kay 1990, Davis *et al.* 2000, Kristensen *et al.* 2000, Jackson *et al.* 2003, Norton *et al.* 2003, 2004, 2007). Mortality of native plant may on one hand decrease plant uptake and on the other release nutrients previously stored in perennial plant biomass (Greenlee and Callaway 1996, Kitzberger *et al.* 2000, Adair *et al.* 2007, Norton *et al.* 2007).

Disturbed sites were dominated by high density of two invasive biennials *Dacus corota* and *Melilotus alba*, but native species dominated at the undisturbed sites. Whereas the seeds of invasive species from its high density sites may have been available throughout the disturbed and undisturbed sites of the habitat. More diverse communities were least accessible to invasion (Levine and D'Antonio 1999, Kennedy *et al.* 2002, Cleland *et al.* 2004, Jiang and Morin 2004, Meiners *et al.* 2004, Hierro *et al.* 2005). The native species in highly diverse communities may have occupied all possible niches and posed stronger competition to invaders for resource and space. Fogarty and Facelli (1999) noted that soil of invaded sites had higher organic carbon, nitrogen and phosphorous than non-invaded sites. The invasion success of *Bromus teclorum* had been linked to high nitrogen (Anonymous 2000, Lowe *et al.* 2003, Monaco *et al.* 2003, Beckstead and Augspurger 2004) and water contents (Link *et al.* 1995, Adair *et al.* 2007, Chambers *et al.* 2007).

Effects of Invasion

Invasive plants modified ecosystem functioning by modifying soil properties and material cycling. Plant induced heterogeneity in soil properties in many ecosystems (Hobbie 1992, Van-Breemen and Finzi 1998, Ehrenfeld 2003). The plant invasion altered the dynamics and composition of community and also modified key ecosystem processes (Ehrenfeld 2003, Levine *et al.* 2003) as the plant traits and ecosystem processes are closely connected (Chapin *et al.* 2002, Hobbie 1992, Van-Breemen and Finzi 1998). The substitution of dominant exotic plants alters the biogeochemical cycles and soil chemistry (Ehrenfeld and Scott 2001, Vanderhoeven *et al.* 2006).

Plant invasion affected organic matter dynamics (Knicker *et al.* 2000, Koutika *et al.* 2007). The soil organic matter dynamics increased after invasion of *Solidago gigantea* and *Prunus serotino* (Koutika *et al.* 2007). Invasion of *Solidago gigantea* increased phosphorous availability at invaded sites (Chapuis-Lardy *et al.* 2006) due to diverse soil microbe activity (Kourtev *et al.* 2002, 2003, Hawkes *et al.* 2005). Invasion of *Prosopis juliflora* significantly reduced soil pH and increased nitrogen, phosphorous, potassium and organic matter (Goel and Behl 1999, El-Keblawy and Al-Rawai 2007). Results of Menezes *et al.* (2002) indicated that *P. juliflora* in semi-arid north-eastern Brazil significantly affected the microclimate, litter dynamics, soil nutrients and may have, in turn increased the rate of nutrient cycling in the system.

Plants after invasion out-compete certain native species and change the structure and function of native communities (Vitousek 1990, Hobbie 1992, Vitousek *et al.* 1996, Gordon 1998, Mack and D'Antonio 1998, Wilcove *et al.* 1998, Frankel 1999, Parker *et al.* 1999, Mack *et al.* 2000, Cronk and Fuller 2001, Johnson and Damman 1991, Woitke and Dietz 2002, Levine *et al.* 2003). The plant invasion causes imbalance in function of natural and agricultural ecosystem and also lead to economic loss (Pimentel *et al.* 2000, Sakai *et al.* 2001, Perrings *et al.* 2002). These imbalances may result in the formation of large monoculture of invasive plants in alien environment. It is thus essential to study the invasion mechanism for timely management (Kohli *et al.* 2004). The impact of an invader can be measured at fine levels viz., at individual, genetic stock, population dynamics, community dynamics and ecosystem process levels (Parker *et al.* 1999). Often invaders became problematic for invaded community due to complex interactions between the traits of the invader and species of the resident community (Mack *et al.* 2000, Lambrinos 2002, Shea and Chesson 2002, Ehrenfeld 2003, Suding *et al.* 2004). Natural disturbance and those caused by human activities are effective invasion promoting factors leading to the spread of non-native species (Hobbs 1989, 1991).

Some plants release allelopathic chemicals in their surroundings that may have deleterious effects on native plants (Callaway 2002). Thus, allelopathy is a dominant invasive trait with ability to modify the structure and function of native community (El-Ghareeb 1991, Vaughn and Berhow 1999, Mallik and Prescott 2001, Ridenour and Callaway 2001, Bais *et al.* 2003, Callaway and Aschehoug 2000, Hierro and Callaway

2003, Levine *et al.* 2003, Orr *et al.* 2005). Some acquired invasive traits of *Lonicera maackii* like high seed production, seed longevity and rapid growth (Trisel 1997) as well as high abundance range, seed dispersal, rapid response to resource availability, high photosynthetic rate and early reproductive maturity (Trisel 1997, Swab *et al.* 2003) led the species out-compete native plants. It is now evident that acquired invasive traits, invasibility of community and resulting changes in the structure and function of ecosystem are webbed together.

Recent investigations have shown that invasive plants have changed several community attributes including species diversity, richness composition and abundance (Prieur-Richard *et al.* 2002, Collier *et al.* 2002, Badano and Pugnaire 2004, Hoffmann *et al.* 2004). The species richness of *Capaniopsis anacauchodes* significantly reduced in Florida (Lockhart *et al.* 1999). Ewe and Sternberg (2003) had shown that dense invasion of *Schinus terebinthifolius* displaced native species and reduced species diversity in Florida and Hawaii in US. The diversity of native species in sites invaded with the *Agave* species was lower than in non-invaded sites in Spain (Badano and Pugnaire 2004). Invasion of an alien grass *Melinis minutiflora* reduced species diversity of native Savanna-forest ecotone in the Brazilian Cerrado (Hoffmann *et al.* 2004, El-Keblawy and Al-Rawai 2007). The plant biomass, diversity, important value index (IVI), richness index, index of diversity significantly reduced in the area invaded with *Parthenium*, *Ageratum* and *Lantana* as compared with community attributes of non-invaded native vegetation (Kohli *et al.* 2004).

Inderjit *et al.* (2005) summarized various hypotheses of invasion success as biotic resistance (Maron and Vilà 2001), resource fluctuation (Davis *et al.* 2000, LeJeune and Seastedt 2001, Grime 2002), superior competitor (Bakker and Wilson 2001, Vilà and Weiner 2004), enemy of enemy is friend (Hay *et al.* 2004), enemy inversion (Pearson and Ortega 2001), increased susceptibility (Colautti *et al.* 2004), invasional meltdown (Simberloff and Von Holle 1999), evolution of increased competitive ability (Blossey and Nötzold 1995), general purpose genotype (Van-Doninck *et al.* 2002), selection of plant invasive ability (Hänfling and Kollman 2002), invasiveness as an evolutionary strategy (Cadotte and Lovett-Doust 2001), human commensal (Rose and Hermanutz 2004), natural community dynamics (Hubbell 2001, Chave 2004), allelopathic advantage against resident species (Callaway and Aschehoug 2000, Bais *et al.* 2003, Callaway and Ridenour 2004), human disturbance that removed competing vegetation (LeJeune 2002, Suding *et al.* 2004) and propagule pressure (Seastedt *et al.* 2003).

Mutual facilitation among exotic species may lead to 'invasion meltdown' where invasive systems facilitate each other resulting in increase invasion rate and replacement of the native species (Simberloff and Von Holle 1999, Simberloff 2006).

Impact of Water and Light on Plant Growth

Water and light stress reduced stem height, leaf number, total leaf area and stem biomass of two invasive brooms namely, *Cytisus scoparius* and *Spartium junceum* (Merchant 1998). Baruch *et al.* (2000) studied impact of three light and two water regimes on two shade intolerant herbs (*Arthrostema ciliatum* and *Tibouchina herbacea*) and two shade tolerant woody species (*Clidemia hirta*-a shrub and *Miconia calvescens*-a tree) and found that their stem height, leaf number, leaf area and stem biomass decreased as their ecological amplitude of water and light had narrower limits. The effect of light stress was stronger than impact of water stress on selected herbs as the species were light sensitive. Similar decrease in relative growth rate of *Cortaderia sellona* and *Cortaderia jubata* had been recorded in response to light and water (Stanton and DiTomaso 2004).

Shading increased the stem length in two sciophytes namely, *Pueraria* *phaseoloides* and *Macroptilium atropurpureum* (Oliveira and Souto 2002). In contrary, the stem height of two sun loving invasive legumes viz., Scotch broom (*Cytisus scoparius*) and Spanish broom (*Spartium junceum*) increased with light intensity (Merchant 1998). Among two cultivation escapes, *Cortaderia sellona* grew more vigorously than *Cortaderia jubata* under high light intensities (Stanton and DiTomaso 2004).

Water stress reduced plant height significantly at all growth stages (Islam and Gretzmacher 2000, Muhammad *et al.* 2001, Pradhan *et al.* 2003, Rahman *et al.* 2002). Water stress during vegetative development reduced cell growth in stem which resulted in reduced plant height (Laura 2003). The decrease in stem height during water stress might be either due to inhibition of cell growth or cell division (Rahman *et al.* 2002). The growth factor was directly correlated with leaf expansion in soybean (Desclauxa *et al.* 2000). In this plant the water deficiency reduced stem height (Grant *et al.* 2005). Boutraa and Sanders (2001) observed in *Phaseolus vulgaris* that water deficiency during reproductive stage (flowering and pod filling stage) reduced stem height, number of branches and number of nodes in main stem.

Water deficiency reduced the leaf size and their number in a several plants (Davidson and Chevalier 1987, Belaygue *et al.* 1996, Blum 1996, Teulat *et al.* 1997, Casper *et al.* 2001, Deblonde and Ledent 2001, Reddy *et al.* 2003, Inman-Bamber 2004, Grant *et al.* 2005). The *Quercus ilex* growing in the Mediterranean holm vok forests is a drought resistant species, but lost its competitive advantage under increasingly drier conditions (Ogaya and Peñuelas 2006). Leaf area is a function of cell expansion, which depends upon turgidity of cells (Boyer 1983). Prolonged suppression of leaf expansion may inhibit or reduce cell division (Meyer and Boyer 1972, Hsiao *et al.* 1976) and hence restrict the potential size of leaf. Wery *et al.* (1994) and Gómez-del-Campo *et al.* (2002)

reported that reductions in leaf area and reduced branching are useful adaptive traits in low rainfall area and shallow soils. According to Collinson *et al.* (1997), reduction in leaf area helped in restricting water loss during dry treatment and enabled the plant to survive soil moisture stress. Plant response to environmental stresses varied with ontogeny (life cycle). The dynamics of stress were directly related with the dynamics of plant ontogeny and development of structure and functions of growing tissues (Roggatz *et al.* 1999).

Water and light are two essential plant growth and life supporting factors. The rate of metabolic functions is mostly related with water content. Relative water content (RWC) is a measure of water status of the tissue, which gradually decreased with increase in water stress in sorghum genotypes (Al-Hamdani and Barger 2003) and chickpea (Rahangdale *et al.* 1994, Islam *et al.* 1998, Deshmukh *et al.* 2000). Relative water content (RWC) of leaf happens to be higher at initial leaf development stages and declined leaf maturity (Jain *et al.* 1997, Reddy *et al.* 2003). High RWC under moisture stress denotes ability of plants to drought tolerance (Misra 1990, Ritchi *et al.* 1990). Sloane *et al.* (1990) measured RWC of two cultivars of soybean at early pod filling stages under well watered and water stressed conditions and concluded that higher RWC was associated with increased seed yield. RWC decreased in response to low and moderate irradiance at early growth stage of buckwheat (Delpérée *et al.* 2003).

Moisture reduces the synthesis of chlorophyll (possibly through nutrient availability (Zheng *et al.* 1992, Gutierrez-Boem and Thomas 1998, Nielson and Nelson 1998, Montage and Woo 1999, Ferus and Arkosiová 2001). Soil moisture reduced nitrogen uptake which adversely affected the chlorophyll contents (Adjet-Twum and Splittstoesser 1976, Yang *et al.* 1996, Awal and Ikeda 2002). Reduction in chlorophyll content under drought condition has been reported in a number of plants (Ashraf *et al.* 1994, El-Kheir *et al.* 1994, Campos 1998, Faria *et al.* 1998, Prakash and Ramachandran

2000, Younis *et al.* 2000, Saxena and Nautiyal 2001, Yang *et al.* 2001, Awal and Ikeda 2002, Al-Hamdani and Barger 2003, Ling *et al.* 2004, Tezara *et al.* 2005). Chlorophyll concentration was more sensitive to water stress in some genotypes at late flowering stage (Garg *et al.* 2004), vegetative, flowering and pod-filling stages (Ashraf and Mahmood 1990, Singh *et al.* 2003, Shubhra *et al.* 2003). Feng *et al.* (2004) worked on 4 tree species and found that chlorophyll content declined with increase of irradiance.

Plant responded to variations in the soil water and oxygen content through morphological, anatomical and physiological adjustment that helped the plants to cope with such conditions (Soriano 1992). It is generally observed that growth resumed after a mild short term stress but cells did not expand fully after the stress was withdrawn. The water stress reduced the number of cells per leaf (Lecoeur *et al.* 1995, Schuppler *et al.* 1998, Granier *et al.* 2000, Tardieu *et al.* 2000). In case of decreased cell production, the apparent after effect on leaf growth may be due to fewer cells produced by leaf meristem (Granier *et al.* 2000).

The vascular bundle sheath often extends to the epidermis. Bundle sheath extensions constitute partitions in mesophyll compartments and thus protect mesophyll from water stress (Terashima 1992). Cell density per unit leaf area in stressed plants thus increases (Tardieu *et al.* 2000). James and Bell (1995) reported that plants from the most arid regions present a thinner spongy mesophyll, a more thickened palisade mesophyll, lager chloroplast and a lower cell density in the epidermis. The mesophyll thickness increased in response to drought (Bussotti *et al.* 1995, Sam *et al.* 1996, Chen and Wen 2005). The leaf thickness under low irradiance and moisture reduced (Witkowsky and Lamont 1991, Groom and Lamont 1997, Niinemets 2001). The leaf thickness and density in evergreen Mediterranean plants increased with worsening ecological conditions (Grossoni *et al.* 1998, Bussotti *et al.* 2000, Mendes *et al.* 2001, Tattani *et al.* 2001).

Epidermis is the most flexible and sensitive leaf component to water deficiency (Stoyanova *et al.* 2002).

Acclimatizing changes in response to drought include decreased stomatal density (Chen and Wen 2005), reduced mesophyll thickness (Zagdanska and Kozdoj 1994, Dami and Hughes 1995), variations in the relative proportion of vascular tissues (vascular bundles), protective tissues (epidermis), photosynthetic cells (mesophyll tissues) and leaf thickness (Chartzoulakis *et al.* 2002, Stoyanova *et al.* 2002). Mature sun and shade leaves are known to sense light signal for anatomical differentiation (Yano and Terashima 2004). The total number of palisade tissue cells did not differ between sun and shade leaves. Under low light condition leaves increased leaf area but not leaf thickness. In contrast, leaf size decreased and leaf thickness increased under high light (Faust 2003).

Higher stomatal frequency proved to be beneficial in ordinary field situations. The plants were better able to take advantage of increased water supply by increasing stomatal conductance (Buttery *et al.* 1993). Variation in stomatal density and distribution in response to environmental stresses needs to be interpreted on the basis of acceleration or deceleration of development (Taylor *et al.* 1994, Schurr *et al.* 2000). Chen and Wen (2005) observed that stomatal density decreased at 30% soil water content in *Fraxinus mandshurica*, *Juglans mandshurica* and *Tilia amurensis* but increased in *Phellodendron amurense*. The decreased stomatal density is considered as adaptation to decreased soil moisture so as to reduce the transpiration.

The number of stomata per leaflet reduced on adaxial and abaxial surfaces due to soil moisture deficiency (Ali 1995, Reddy *et al.* 2003, Ratnayaka and Kincaid 2005). In contrary, the stomatal density was not affected by water stress in soybean (Inamullah and

Isoda 2005). Stomatal index increased in a perennial grass *Leymus chinensis* in response to soil water stress (Xu and Zhou 2005).

Impact of Water Stress on Reproductive Growth

Most of rainy season species require a specific range of water and clear sunshine days. Water is used throughout the lifecycle. An influx of water from vegetative portions of plant was required for floral bud expansion, flower opening, nectar production and turgor maintenance in floral organs under evapo-transpirational demand (Boote and Ketring 1990, Stirling and Black 1991, Reddy *et al.* 2003). The water regime and light conditions may alter onset of reproductive phase (Nakajima *et al.* 1993, Galán 1999) or may adversely delay flowering (Craufurd *et al.* 1993, Pradhan *et al.* 2003, Caruso 2006, French 2006). Water deficiency also reduced size of floral buds and flower (Caruso 2006).

Low soil moisture delay or inhibit floral bud initiation (Garcia *et al.* 2004). The fruit setting and seed yield depends upon the number of floral buds (Westgate and Peterson 1993, Ney *et al.* 1994, Lopez *et al.* 1996). Water deficiency induces abortion of reproductive organs including ovaries, floral buds or flowers (Westgate and Peterson 1993, Kokubun *et al.* 2001, Bissuel-Belaygue *et al.* 2002, Barrios *et al.* 2005, Turner 2005) or fruits (Mwanamwenge *et al.* 1999). The drought stress treatment slightly hastened flower initiation and decreased the total number of flowers per plant (Westgate and Peterson 1993, Caspari *et al.* 1994, Mills *et al.* 1994b, Behboudian and Mills 1997, Pszczółkowska *et al.* 2003, Barrios *et al.* 2005, Cawoya *et al.* 2006). On the contrary, the water deficiency increased bloom density in certain subtropical species (Nakajima *et al* 1993) and also in some temperate fruit crops (Raese *et al.* 1982, Mitchell *et al.* 1984, Chalmers *et al.* 1985). The number of pods per unit vegetative dry matter was significantly affected by stress during pod elongation. Early stress during seed filling reduced the number of seeds per pod whereas late stress (after the abortion limit stage) decreased seed weight (Desclauxa *et al.* 2000). Deficient light may delay and inhibit flowering or reduce floral bloom (Faust 2003).

Drought stress at the stage of flowering to pod filling reduced yield due to reduction of branches (Board *et al.* 1990, Acosta-Gallegos and Adams 1991, Frederick *et al.* 1991, Pilbeam *et al.* 1992, Vieira *et al.* 1992, Xia 1994, Singh 1995, Castellanos *et al.* 1996, Lopez *et al.* 1996, De-Souza *et al.* 1997, Board and Harville 1998, Nielson and Nelson 1998, Linkermer *et al.* 1998, Boutraa and Sanders 2001, Vega *et al.* 2001, Brevedan and Egli 2003). Flower, seed and fruit production was adversely affected as plant biomass reduced owing to water stress (Sharma and Sivakumar 1991, Westgate and Peterson 1993, Desclauxa *et al.* 2000, Pszczółkowska *et al.* 2003). Ian Goodwin (2002) observed that the water stress level and timing of stress is more crucial in affecting the growth and development of shoots, leaves and fruit. Water stress initiate during vegetative or early reproductive growth of soybean usually reduces yield by reducing seed number (Guilioni *et al.* 2003, Armstrong *et al.* 1996, French 2006). In contrary, Guntoni and Evenson (1980) noted that seed yield was not very detrimental when plant faced water stress during vegetative stage.

Inferences from the review

The autecological life cycle of invasive species has not been studied exclusively to compare the behavior of species under varying set of environments. The effect of varying water regimes on vegetative and reproductive growth of invasive species may be considered as a measure of the phenotypic plasticity. The allelopathic impact of root exudates of some dominant and least frequent native species of invaded community shall be studied to work out if invasive plants faced any resistance from the native species. The autecological studies of invasive species may more clearly indicate the extent of impact on plant community and vice-versa. If the targeted invasive plant grows along with any other invasive species in any ecosystem, then it will be more appropriate to study the allelopathic impact of targeted on non targeted invasive species and vice-versa. Because both invasive species may have developed some bonds of proto-cooperation and influence on community characteristics may have been complex. This approach may be helpful in determining the principle of enemy of enemy is friend or invasional meltdown may have been caused by one of them to the advantage of the other.

The light and water stress influence the plant invasion. Therefore, effect of water stress shall be studied on a variety of growth parameters. Water stress either at vegetative or reproductive growth stage may influence invasive traits. Therefore, the effect of water stress shall be studied at both the stages.

Materials and Methods

MATERIALS AND METHODS

Selection and Collection of Plant Material

The responses of two selected invasive species namely, *Mirabilis jalapa* and *Ruellia tuberosa* was worked out throughout their ontogeny by studying the autecological parameters and survivorship pattern in pots and invaded field. The plants of both the species were maintained in pots under varying soil moisture and light intensities. The impact of root exudates of some component species (at invaded sites) was also determined.

Brief Botanical Description of Selected Plants

a) *Mirabilis jalapa* L.

Systematic position: *Mirabilis jalapa* is placed under order Curvembryae and family Nyctaginaceace (Bentham and Hooker 1862, Engler and Prantl 1931, Duthie, Fl. Gangetic plain 3:3, 1915). Common names are 4 o'clock plant, marvel of Peru and Gul-Abbas.

Description: Stem 20-100 cm erect, aerial, herbaceous, branched, cylindrical, pinkish green, swollen nodes, roots tuberous. Leaves cauline and ramal, opposite petiolate, simple, entire, exstipulate, ovate, acute and glabrous. Flowers crowded in lax leafy corymbs. Bracts divided halfway down. Perianth red, white, yellow or variegated, glandular hairy. Stamens 5, exserted. Anthers yellow. Anthocarps globose, 5-ribbed, black on maturity. Fruit nutlets, globose.

Distribution: *Mirabilis jalapa*-a native of tropical America is commonly cultivated in North America. This species was initially cultivated as ornamental in some parts of tropics and later escaped and naturalized into wild throughout the tropics (Smith 1981, Reddy 2008).

The *Mirabilis jalapa* was introduced in India as an ornamental. This species naturalized as invasive weed in cultivated field, waste grounds as well as roadside and rail tracks. It grows well as weed in moist and well drained soils of garden (Huxley 1992).

Propagation: *Mirabilis jalapa* propagate by seeds and tubers. Seeds remain viable for several years. The large elongated tubers make large specimen difficult to transplant.

Uses of plant: This plant is grown as ornamental in beds and often mixed with hedge. Leaves are often used as edible leafy vegetable (Tanaka 1976, Kunkel 1984, Facciola 1990). An edible crimson dye is obtained from the flower (Uphof 1959, Usher 1974, Tanaka 1976, Kunkel 1984, Facciola 1990). The dye is used in syrups and other medicines for coloring. Seeds are crushed and used as a pepper substitute (Tanaka 1976, Kunkel 1984, Facciola 1990).

This plant has been credited with some medicinal properties. It is used as a supperative, laxative herb and in curing scabies and itches. A protein is purified from the root tubers and used as an antiviral protein (Kataoka *et al.* 1991, 1992, Wong *et al.* 1992). A paste of root mixed with milk works as a laxative but with violent cathartic effect. The root is aphrodisiac, diuretic and purgative. Its roots are used in treatment of dropsy (Duke and Ayensu 1985, Chopra *et al.* 1986). Leaves are used to reduce inflammation (Chopra *et al.* 1986) and healing of wounds (Duke and Ayensu 1985). Powdered seeds are used in cosmetics (Uphof 1959, Usher 1974). Antimicrobial peptides from seeds have also been detected and characterized (Cammue *et al.* 1992, De Bolle *et al.* 1995).

b) *Ruellia tuberosa* L.

Systematic position: *Ruellia tuberosa* is placed under order Personales and family Acanthaceae (Bentham and Hooker 1862, Engler and Prantl 1931, Duthie, Fl. Gangetic plain 209: 1976). Common names are Blue bell, Daniel's great gun, large bell flower, Minneroot, Watercanon, Waterkamu, Popping Pod plant.

Description: Stem erect, Leaves ascending, opposite, simple, exstipulate, petiolate, oblong to obovate. Flowers paired in leaf axial, blue-violet. Bracts linear-subulate. Calyx lobes linear, ciliate. Corolla tube abruptly narrowed below. Stamens 4, introse. Bicarpallary, syncarpous, superior, bilocular ovary 2 or more anatropous ovule in each locule. Capsule linear, fusiform, grooved dorsiventral. Seeds many, ovate-oblong.

It is an erect annual herb up to 75 cm height with tuberous roots. *Ruellia tuberosa* prefers shade and thus occurs amongst medium trees and herb fields. It prefers loam wet soil but may also occur on the margins of salt marshes (subject to inundation close to creek lines), riverbanks, lawns, wastelands, irrigated lands and gardens.

Distribution: It is a native of tropical America and West Indies. It was introduced in India as garden ornamental. It now grows spontaneously in garden hedge around lawns. Now, it is naturalized on waste places as invasive species near gardens (Whistler 1988, Meyer and Lavergne 2004, Reddy 2008). *Ruellia tuberosa* propagate by seeds and cutting.

Uses of plant: It is used as ornamental plants and also as an anthelminthic against joint pains and strained muscles. This herb possesses emetic properties and is employed as a substitute for ipecacuanha. It is also used in the treatment of stones in the bladder. A decoction of the leaves is given in chronic bronchitis.

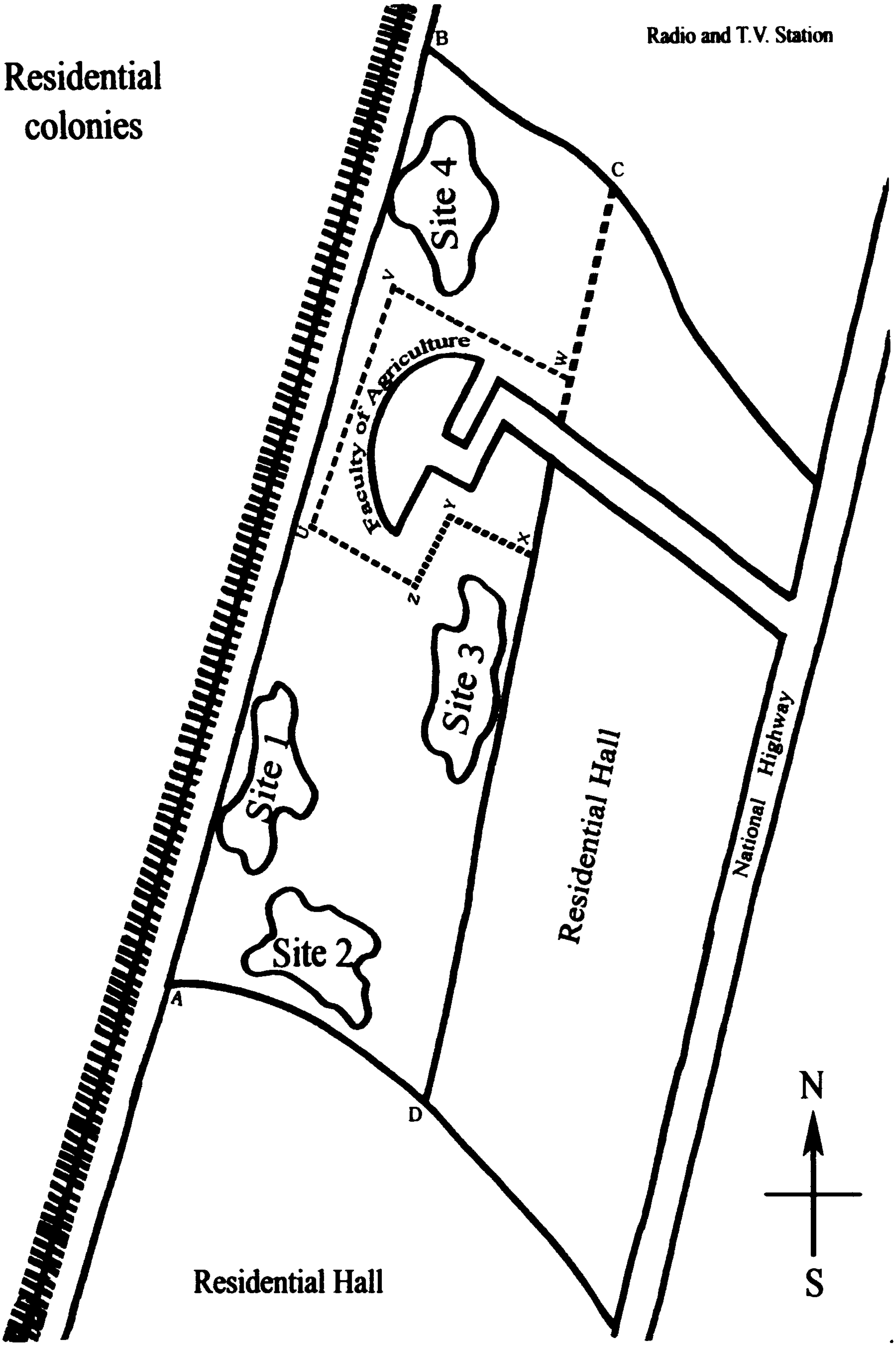
Selection of Sites

A field recently invaded by *Mirabilis jalapa* and *Ruellia tuberosa* was selected for the present studies. The major part of the field was under cultivation until acquired in 1997 by the University. The field was protected by boundary wall from three sides (North, East and West) and fenced from the southern side. The entire acquired and fenced area of several hectares remained free from anthropogenic activities and cattle etc. for several years before it was allotted to Faculty of Agriculture.

One large patch located along railway track side and invaded by *Mirabilis jalapa* was selected as **Site 1**. *Ruellia tuberosa* is relatively more frequently distributed. Two patches invaded by *Ruellia tuberosa* were selected and marked as **Site 2** and **Site 3**. The Site 2 was located closer to the railway track side (the south-western fringe side) but about 200-300m away from Site 1 and Site 3 (Map). One more patch non-invaded by both the selected species (located on the north-western side of the field) was also selected as **Site 4** to compare the community structure of native species with those of the invaded community (Map). The probability of pre-existing difference in soil properties was minimized by selecting all 4 sites in a single field. The same comparative approach was successfully applied to investigate impacts of invasive plants by McIntosh *et al.* (1995), Ehrenfeld *et al.* (2001), Scott *et al.* (2001) and Hook *et al.* (2004). A large number of native wild plants have since invaded into the selected field, beside non-native *Mirabilis jalapa* and *Ruellia tuberosa* at some places.

Soil Analysis

The soil of pots and upper 30cm layer of all 4 selected sites was analyzed for per cent moisture, organic matter and NPK. The detailed methods of soil analysis are annexed at the end of the materials and methods.



Map: Location of 4 selected sites in the selected field (ABCD coordinates). The field (6.97 hectares) includes part occupied by the building of faculty of Agriculture (coordinates UVWXYZ).

Plate 1

A – State of community structure at **Site 1** invaded by *Mirabilis jalapa* in July.

B – State of community structure at **Site 2** invaded by *Ruellia tuberosa* in September.

C – State of community structure at **Site 3** invaded by *Ruellia tuberosa* in September.

D – State of community structure at native species of non-invaded **Site 4** in July.

Bars equal to 100mm.

Plate 1

The experimental pots had uniformly lower contents of **organic matter** than in the field. The organic matter was highest at Site 2 and 3 (invaded by *Ruellia* species) followed by Site 1 (invaded by *Mirabilis* species) and least at non-invaded Site 4. The organic matter content considerably high at invaded sites (1, 2 and 3) in the month of February and July feasibly due to death and decay of the component species of winter and summer seasons (Figure 1A). The **soil moisture** in the pots was higher (as it was maintained) as compared to selected sites. Among the selected 4 sites, the moisture level was relatively higher at Site 3 followed by Site 4, Site 1 and Site 2 (Figure 1B). The **nitrogen, phosphorus and potash** (NPK) content was also lower in pots as compared to selected sites. Site 3 was slightly richer in N and K content and Site 2 in P content as compared to other sites throughout the year (Figure 2A, B and C).

Light Intensity

The light intensity around the sites of experimental pots and at selected sites was recorded at monthly intervals at 11:00 am and 3:00 pm (local time) with the help of a lux meter (Elico, Elico Ltd., Hyderabad, India). The **light intensity** was higher at Sites 1, 2 and 4 as compared to experimental sites of pots and Site 3 (Figure 1C).

Community Analysis

In addition to the studies on autecological life cycles and survivorship of selected species, some community attributes were also studied at monthly intervals in 5 randomly laid down quadrats of 25×25 cm^2. The following community attributes were studied at all the selected sites:

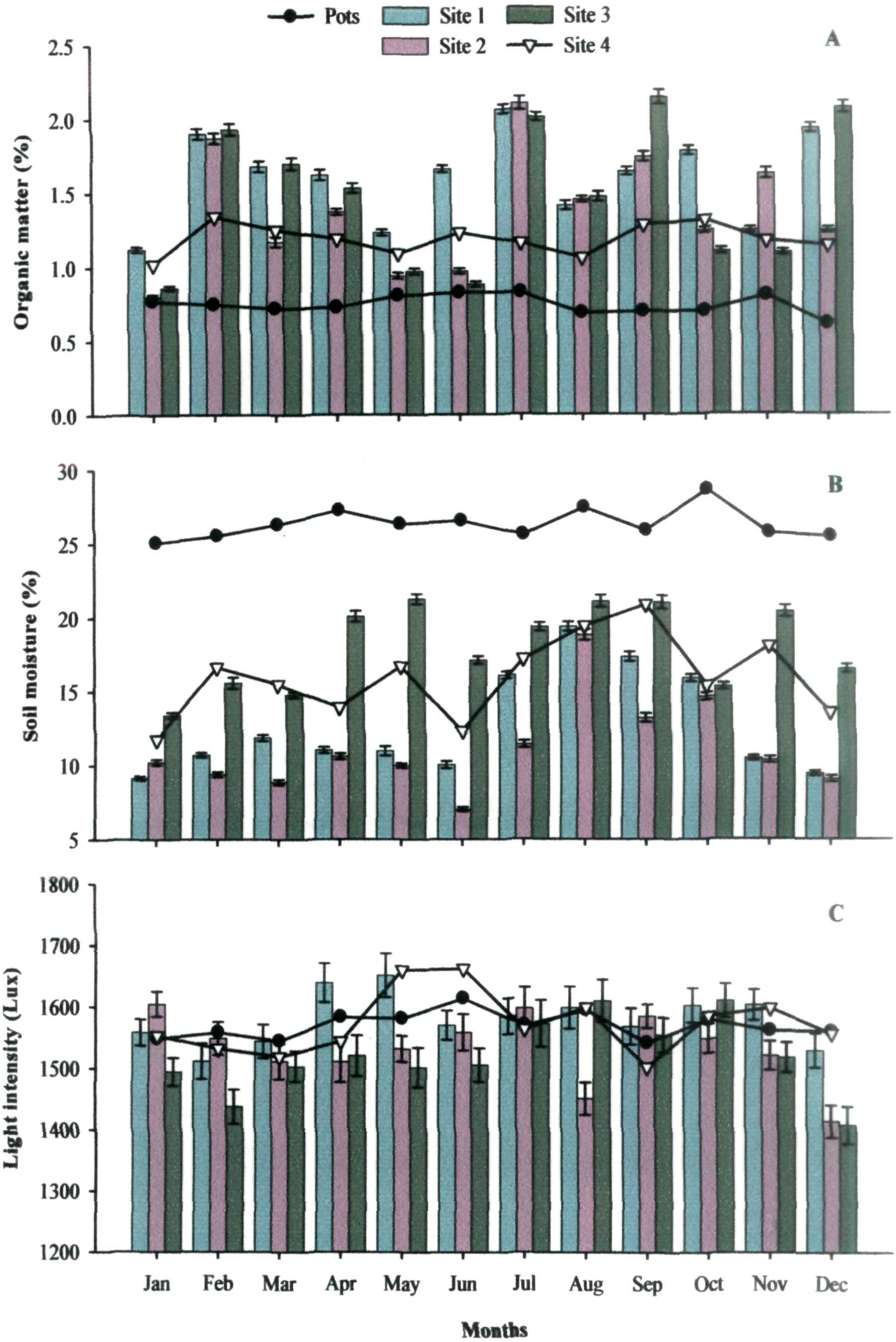


Figure 1 (A, B and C). Monthly average of organic matter (%), soil moisture (%) and light intensity (Lux) in pots and at selected sites.

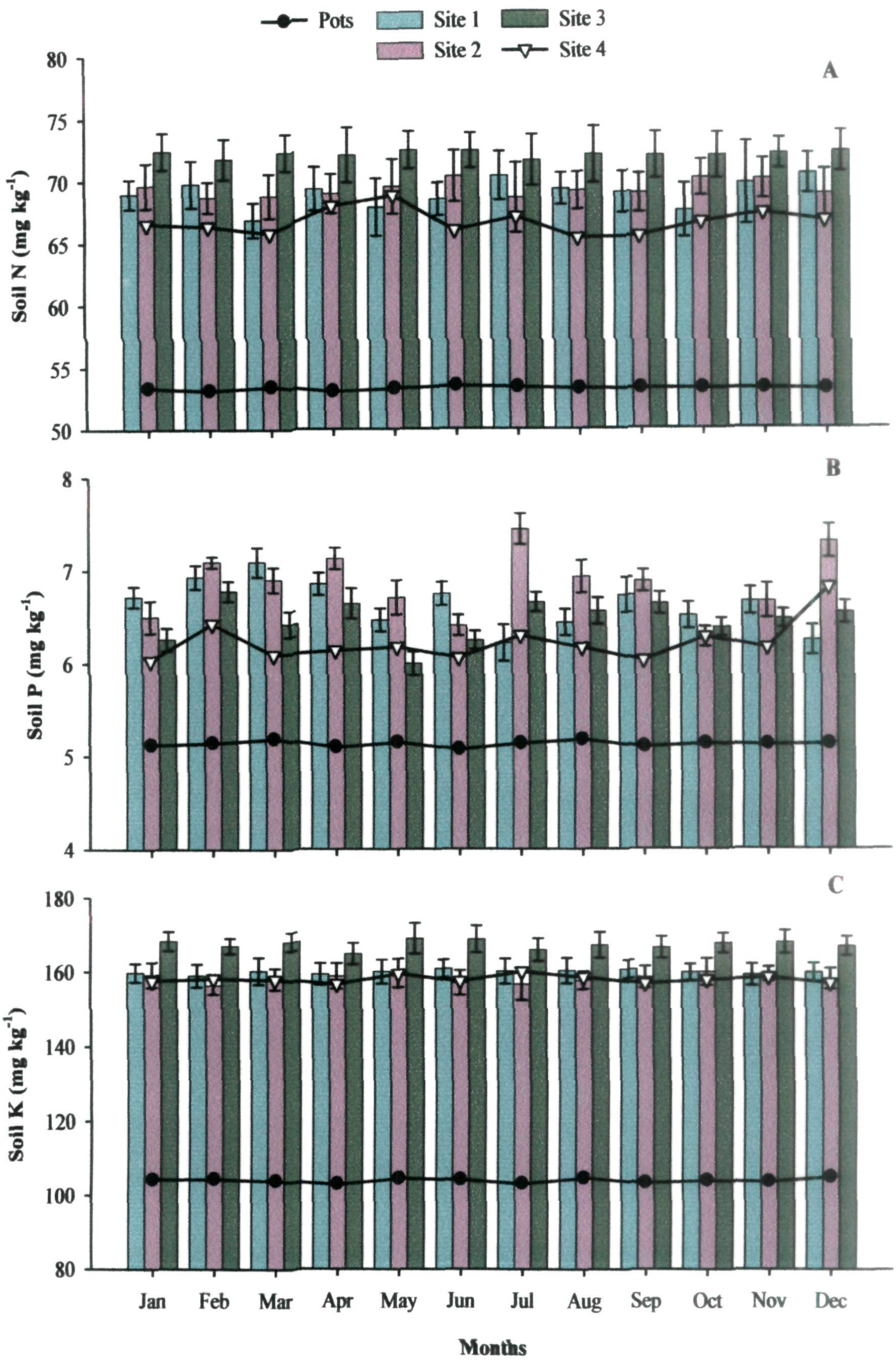


Figure 2 (A, B and C). Monthly average of soil nitrogen (N), soil phosphorus (P) and soil potassium (K) in pots and at selected sites.

Abundance

Abundance of a species was calculated by following formula –

$$\text{Abundance} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats in which species occurred}}$$

Relative Frequency

Frequency refers to the degree of dispersion in terms of per cent age occurrence. Relative frequency of a species was determined as follows –

$$\text{Relative frequency (\%)} = \frac{\text{Total number of quadrats in which species occurred}}{\text{Total number of quadrats laid down}} \times 100$$

Relative Density

The numerical strength of the species in relation to unit space is called its density. The proportion of density of the species to that of stand as a whole is referred as relative density and determined as follows –

$$\text{Relative density (\%)} = \frac{\text{Total number of individuals of a species}}{\text{Total number of individuals of all species}} \times 100$$

Relative Dominance

The relative dominance was calculated by working out the basal area of species. The basal area was determined separately at monthly interval before laying down quadrat. The diameter of 10 randomly selected individuals of each component species was determined and average diameter of each species was worked out. The basal area was computed by πr^2 (r = diameter/2). The average diameter was multiplied by number of individuals in each quadrat. The relative dominance was calculated as follows -

$$\text{Relative dominance (\%)} = \frac{\text{Total basal area of a given species in all the quadrats}}{\text{Total basal area of all the species in all quadrats}} \times 100$$

Important Value Index (IVI)

The IVI is used as a single numerical value to denote the ecological success or importance of any species in a community. It was calculated following Curtis (1959).

$$IVI = RF + RD + RDom.$$

Where, RF = Relative frequency, RD = Relative density, RDom. = Relative dominance

Ecological Indices

All selected community patches were analyzed for species richness, evenness, diversity, and dominance through ecological indices to reduce complexity of data (Whittaker 1953). Though a great variety of indices are available, but only a few indices such as Margalef's richness index, Hill's evenness index, Shannon's diversity index and Simpson's dominance index were determined as considered précised and widely applicable (Ludwig and Reynolds 1988).

Richness Index

Richness is an indicator of the relative wealth of species in a community. Richness is often measured as the number of species in the samples of arbitrarily chosen (constant quadrat size). Richness index, a measure of numerical strength of vegetation, was calculated by the formula of Margalef (1958) as follows –

$$\text{Margalef's richness index (R)} = \frac{S-1}{\ln N}$$

Where, S = Total number of a species, N = Total number of individuals of all species

Dominance Index

The dominance index shows the variability in the community. Higher index shows greater homogeneity and vice versa. Homogenous communities are dominated by a single species. Dominance index was measured as per the formula given by Simpson (1949).

$$\text{Simpson's dominance index } (\lambda) = \sum_{i=1}^{S}\left(\frac{n_i}{N}\right)^2$$

Where, s = total number of species, N = total number of individual of all species, n_i = number of individual of the *i*th species

Diversity Index

The diversity index Shannon and Weaver (1963) accounts for the abundance and the evenness of the species in a natural environment. It is used to assess the impact of selected species on the diversity of herbaceous plant species. The higher value of index of diversity shows variability in the species composition indicating heterogeneity in the community. The lesser index values point to the homogeneity in the community.

$$\text{Shannon's diversity index } (H') = -\sum_{i=1}^{S}\left(\frac{n_i}{N}\right)\ln\left(\frac{n_i}{N}\right)$$

Where, n_i = the importance value of the *i*th species, s = total number of species in the sample quadrat, N = total number of individual of all species

Evenness Index

The evenness of species was calculated following Hill (1973). This index explains how equally abundant each species would be in a given plant community. High evenness is a sign of ecosystem health indicating undisturbed community. The communities with evenness do not have any single dominating species in the ecosystem. The evenness or equitability assumes a value between 0 and 1, with 1 being complete evenness and 0 a single species dominating the area.

$$\text{Hill's evenness index (E)} = \frac{H'}{\ln S} \text{ or } \frac{-\sum_{i=1}^{S}\left(\frac{n_i}{N}\right)\ln\left(\frac{n_i}{N}\right)}{\ln S}$$

Where, H′= index of diversity, S = total number of species, N = total number of individuals of all the species, n_i = number of individuals of the *i*th species

Pot Experiments

The selected species were grown in pots to study the following –

- The life cycle of selected plants under cultivated conditions with adequate moisture.
- The effect on the growth of the selected species of varying soil moisture at pre- and post-reproductive stages.
- The effect of varying light intensities on the growth of selected species.
- The effect of root exudates of some selected co-occurring species on the growth of the selected invasive species.

Pot filling and Seed Sowing

Seed of *Mirabilis jalapa* and *Ruellia tuberosa* were collected from an adjacent field under cultivation of ornamental plants including *M. jalapa*, *R. tuberosa* and *Catharanthus roseus* etc. The timings of pot experiments of both the species varied with their season of germination. All pot experiments were conducted in 30cm × 20cm size (L×D) filled with garden soil and farmyard manure (4:1) and autoclaved.

Seeds of *Mirabilis jalapa* (soaked overnight in distilled water) were sown at the rate of 4 seeds/pot in the first week of January. After germination, the thinning was done to leave 1 plant/pot. The studies on the life cycle of pot cultivated plants and the impact of variable water regimes on its growth were conducted in 2005. The impact of varying light regimes and root exudates (of some species co-occurring in the field) was studied (in pots) separately in the following growth season (2006).

In the 2nd week of April 2006, ten seeds of *Ruellia tuberosa* were sown in each pot (as specified above). After germination all pots were thinned to leave one plant of equal growth vigour in each pot. The studies on the life cycle in pot and the impact of variable water regimes on its growth were conducted in 2006. The impacts of varying light regimes and root exudates of five species co-occurring in the field with *Ruellia tuberosa* was studied in the following growth season (April 2007).

Exprimental Design

The experiments were conducted following randomized complete block design method (Dospekhov 1984).

Replication

Five pots each with one plant were used for the study of biological clock. Three pots were used as replicate for each variable for the studies on varying water levels, light and root exudates. In all experiments, the pots of each dose were placed randomly but at 60cm regular distance.

Selected Water Regimes

The effects of five varying levels on the growth of selected plants were studied at pre-flowering (30 days old age) and post-flowering (60 days old age) stages in separate sets of experiment. In each set of experiments, the pots were subjected to varying water levels for five weeks (starting either at pre- or post-flowering stage). The watering schedule is given below-

W_1 – Daily watering (at 24hrs)

W_2 – Watering at alternate days (at 48hrs)

W_3 – Watering at 3 days interval (at 72hrs)

W_4 – Watering at 5 days interval (at 120hrs)

W_5 – Watering at 10 days interval (at 240hrs)

The life cycle of both the selected plants was studied on five marked individuals at each invaded site and also on five individuals of pots maintained with adequate moisture in the nursery of the Department of Botany, Aligarh Muslim University. The growth stages of both the selected species were recorded at monthly intervals.

Selected Light Regimes

There was some variation in the luminance at the selected sites. It was felt necessary to work out the effect of light variation on the growth before attributing invasibility of the ecosystem or phenotypic plasticity of species to varying soil moisture alone. The impact of three varying light regimes on growth of selected invasive plant was also worked out. The selected species grown in pots with adequate moisture were exposed to three variable light regimes at pre- and post-flowering stages. The selected light regimes were as follows –

Mirabilis jalapa

S.No.	Light Regime	Luminance (Lux)		Place
		30 days	60 days	
1.	Open light	1550±21.8	1518±45.5	Pots were kept in open
2.	Partial shade	1249±56.16	1236±65.8	Pots were kept under canopy of a tall tree
3.	Shade	451±51.4	466±42.5	Pots were kept under a dense canopy

Ruellia tuberosa

S.No.	Light Regime	Luminance (Lux)		Place
		30 days	60 days	
1.	Open light	1503±45.6	1498±47.4	Pots were kept in open
2.	Partial shade	1229±61.6	1195±57.7	Pots were kept under canopy of a tall tree
3.	Shade	461±35.4	451±44.2	Pots were kept under a dense canopy

Root Exudates Treatments

The invasive species may also face allelopathic impact of the root exudates of native species besides water stress. Therefore, the impact of root exudates of some native species co-occurring with each selected invasive species in their respective sites was also studied. For the study of the impact of root exudates, only few selected component species with either very low or high IVI values were selected as listed below:

Mirabilis jalapa
(IVI of Site 1 =191±16)

Species selected for root exudates	IVI(mean±SD)
	Site 1
Argemone mexicana	56±85
Malvastrum coromandelianum	54±36
Parthenium hysterophorus	122±23

Ruellia tuberosa
(IVI at Site 2=178±16; Site 3=166±34)

Species selected for root exudates	IVI(mean±SD)	
	Site 2	Site 3
Achyranthes aspera	79±35	52±29
Bidens pilosa	-	49±23
Capparis sepiaria	129±64	-
Malvastrum coromandelianum	77±19	43±24
Unidentified Acanthaceae	63±22	64±37

Doses of Root Exudates

The effect of 100 ml, 200 ml and 400 ml of root exudates of aforementioned plants on the growth of the respective invasive plant was studied at pre- and post-flowering stages. The selected doses of 100 ml, 200 ml and 400 ml were equivalent to the root exudates of 1, 2 and 4 plants, respectively. One set of control without root exudate was also maintained.

Extraction of Root Exudates

The root exudates of desired plants were extracted following the method of Aggarwal *et al.* (1999). Fresh intact roots of twenty five plants of the desired component species were collected from the field, washed thoroughly, rinsed with distilled water (DW) and soaked 1500ml distilled water for 72 hrs and subjected to gentle shaking for 1.0 minute. 25mg silver oxide was added to control microbial activity. The extract was filtered with Whatman filter paper No. 1. The final volume was made to 2500ml. The 100 ml of this stock solution was equivalent to the root exudate of one plant.

Autecological Studies

The community attributes of the selected sites were studied only as part the characteristic structure of selected sites. The main objective of the present work was to study the effect of soil moisture on the invasibility of two selected species. The studies on the effects of variable light and root exudates were also added to support the discussion on the invasibility of selected species.

Parameters Studied

The growth parameters are the measure of the response of any invading species to the new set of environmental variables of the invaded ecosystem. The following growth parameters were selected and recorded at monthly intervals to study the life cycle of selected species in field and pots. The impact of variable water regimes and other sub variables (light and root exudates) was studied at weekly interval. The stem biomass, reproductive capacity and histological parameters were recorded in field and pot experiments only on the termination of experiment (mature stage).

a) Survivorship Curves

For standing population and mortality curves, the trend of population growth and survival of *Mirabilis jalapa* and *Ruellia tuberosa* was studied at monthly intervals in their invaded community at Site 1 and Sites 2–3, respectively. The standing population of both the selected species in $1m^2$ has been projected out of number recorded in 25×25 cm^2 quadrat laid down during community study. This number includes the surviving individuals of *Mirabilis jalapa* germinated during January to mid February and those germinated unusually in July. The *Ruellia tuberosa* population also includes individuals germinated in month of April and those germinated unusually in July. Thus the number of individuals in $1m^2$ represents only the standing population. To study the virtual survival and mortality curves, three sets of 50 randomly selected individuals of *Mirabilis jalapa* germination in the month of January at Site 1 and *Ruellia tuberosa* germinated in the month of April at Site 2 and 3 were marked. After marking, the numbers of surviving individuals were recorded at monthly intervals until maturity and complete drying of all marked individuals.

b) Biological Life Cycle

The monthly growth stages of both the selected species growing at the selected sites and cultivated in pots (with adequate water) were studied and presented as biological clock or life cycle.

c) Vegetative Growth Parameters

The state of plant growth indicates sum of the impact of environmental variables. The following growth parameters were studied–

i) Plant Height

The length of main stem of the individuals of selected species was measured from ground to the plant tip using a meter scale.

ii) Leaf Number

The number of fully expanded leaves were counted and expressed as leaf number per plant.

iii) Leaf Area

Margin of 5 leaves above 3rd or 4th internodes of both the invasive species were mapped on rice paper and the area of each mapped leaf was directly measured by a planimeter, averaged and expressed as leaf area.

iv) Total Leaf Area

Total leaf area was computed by multiplying the average number of leaf per plant and average leaf area of respective set of plants.

d) Physio-biochemical Parameters

The following growth related physiological and biochemical parameters were studied:

i) Relative Water Content

Relative water content (RWC) was determined by the method of Barrs and Weatherley (1962). 500mg fresh leaf material was soaked in distilled water for 2 hrs to make the leaf tissue turgid. The turgid weight of the leaf material was taken after carefully absorbing excess water from the surface of leaf tissues by using blotting papers. The leaf material was kept in a butter paper bag and dried in oven at 85^{0}C for 24 hrs and their dry weight was recorded. The relative water content was calculated by using the following formula –

$$\text{RWC}(\%) = \frac{\text{Fresh weight - Dry weight}}{\text{Turgid weight - Dry weight}} \times 100$$

ii) Chlorophyll Estimation

The chlorophyll contents of plants (chl-a, chl-b and total chl.) was determined by grinding 100mg fresh green leaf tissues in 5ml acetone (80%) with the help of mortar and pestle. The suspension was decanted with funnel having Whatman filter paper No. 1. The supernatant was rewashed with 3ml of 80% acetone through the filter paper. The filtrate was taken in a graduated test tube and final volume was made up to 10ml with 80% acetone. The optical density of chlorophyll solution was read at 645nm and 663nm wave lengths with the help of Spectrophotometer (spectronic-20 Elico, Elico Ltd, Hyderabad, India). The chlorophyll contents were calculated according to the formula given by Arnon (1951) (further elaborated by Ekanayake and Adeleke 1996) as-

$$\text{Chl–a (mg/g of fresh tissue)} = \frac{12.7\,(\text{O.D.663}) - 2.69\,(\text{O.D.645})}{1000 \times W} \times V$$

$$\text{Chl–b (mg/g of fresh tissue)} = \frac{22.9\,(\text{O.D.645}) - 4.68\,(\text{O.D.663})}{1000 \times W} \times V$$

$$\text{Total Chl. (mg/g of fresh tissue)} = \frac{20.2\,(\text{O.D.645}) + 80.2\,(\text{O.D.663})}{1000 \times W} \times V$$

Where, OD = Optical density at given wavelength viz. 663nm and 645nm, V = Total volume if chlorophyll extract in 80% acetone, W = Fresh weight of plant tissues in 'g'

iii) Stem Biomass

After recording parameters (height, leaf number and leaf area) all 5 randomly selected individuals of both the species were oven dried (at 80^0C for 48 hrs), weighed on electric balance (Elico, Elico Ltd., Hyderabad, India) and expressed as stem biomass per plant. The dry weight of above ground parts of the 5 cultivated individuals of both the species maintained in pots (for the study of life cycle) was taken only after termination of the experiment after one year. Dry weight of individuals treated with variable water, light and root exudates was recorded on termination of the experiment after 5 week of treatment.

e) Histological Parameters

i) Stomatal Observation

Stomatal density was studied using clear nail polish impressions of leaf epidermis following the method of Teare *et al.* (1971). Thin layer of nail polish was applied on one side of mid rib at the middle of the leaf. A small strip of clear cellophane tape was gently pressed over the dried nail polish. The tape was peeled off from the leaf and affixed on a clear microscopic slide.

The stomata and epidermal cells in a 1cm^2 area of eye piece (= 0.41mm^2 of leaf surface) were counted under the microscope. The stomatal Index (S.I.) was calculated following the formula Salisbury (1927) –

$$S.\,I. = \frac{S}{S + E} \times 100$$

Where, S and E represent the number of stomata and epidermal cell per 1cm^2 area of eye piece, respectively.

ii) Proportion of leaf tissues

1) Selection and Collection

Three healthy and fully expanded leaves (3rd - 4th internode) of both the selected species were collected at the time of the termination of the experiment/field studies. The leaves were preserved in 70% alcohol after fixing in FAA as described below–

2) Fixation and Preservation

Soon after collection, leaves were fixed in Formalin-aceto-alcohol (FAA) mixture. The FAA was prepared by mixing Formaldehyde, Glacial Acetic Acid and

Ethyl Alcohol as given below-

Ethyl Alcohol 100%...45mL

Glacial Acetic Acid.................................5mL

Formaldehyde...5mL

Distilled water.......................................45mL

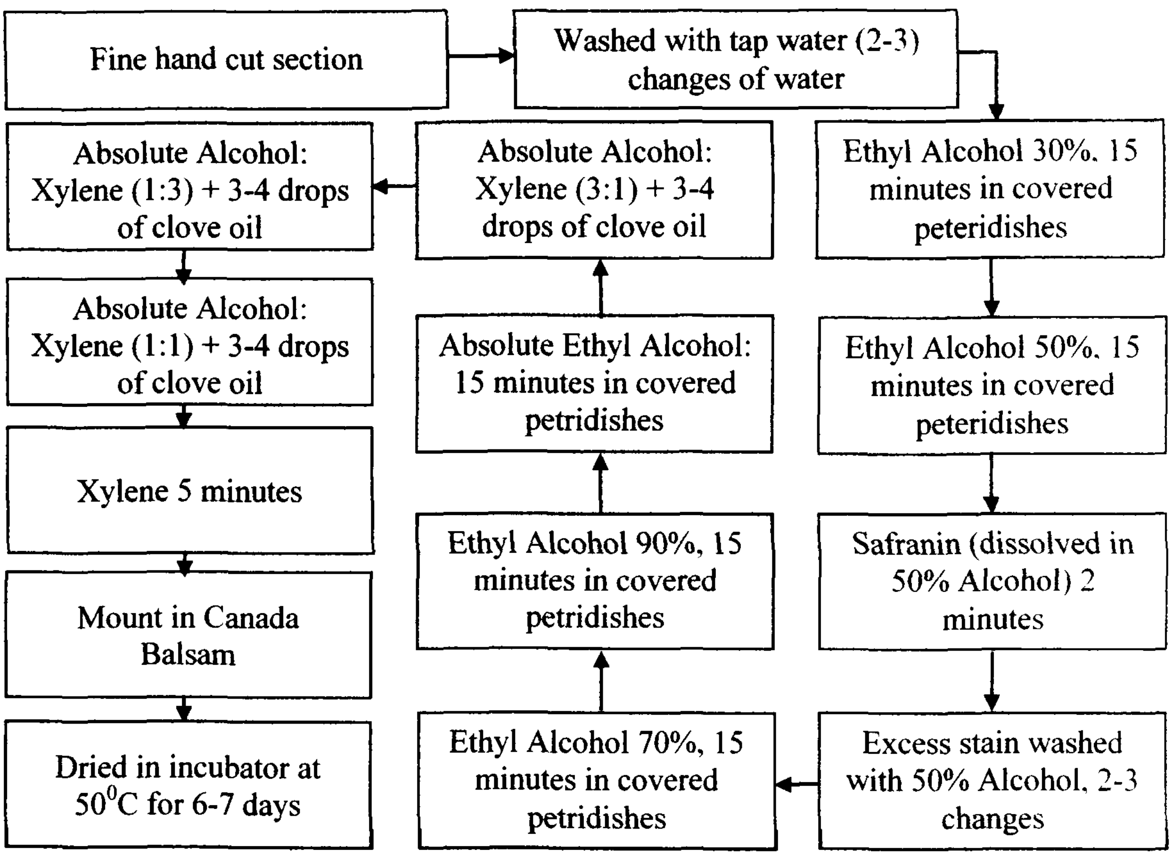
The collected samples were kept for 12 hrs in FAA for fixation. The samples were transferred to 70% Ethyl Alcohol for preservation.

3) Sectioning and Staining

Free hand sections of each preserved leaf material were prepared. The sections were dehydrated in alcoholic series, stained with safaranin and mounted in Canada balsam as per the past practice of the laboratory (Zaidi 1984).

4) Dehydration and Staining Scheme

The following scheme of dehydration, staining and mounting was followed:



f) Reproductive Growth Parameters

Reproductive growth is the measure of plants ability to re-establish itself in an invaded ecosystem. Certain reproductive traits are among important invasive characteristic. The invasive characteristics not only include long flowering span but also qualitative and quantitative increase in the output of floral buds, flower, fruit and seed. Following reproductive parameters were studied-

i) Number of Floral Buds, Flowers and Fruits

Standing floral buds, flowers and fruits were counted, averaged and expressed as floral bud number, flower number and fruit number per plants.

ii) Average Seed Output

The total number of seeds per plants was counted, averaged and expressed as number of seeds per plants.

g) Reproductive capacity

Per cent reproductive capacity was calculated by following formula utilizing the values of the average seed output and percent germination–

$$\text{Per cent reproductive capacity} = \frac{\text{Average seed output} \times \text{Per cent germination}}{100}$$

Statistical Analysis

The data of pot experiments were analyzed statistically following Dospekhov (1984).

a) Mean

The arithmetic mean or simple mean or the so called average value was easily computed by taking the sum of a number of values (X_1, X_2, X_3,.......X_n) and dividing it by the total number of value (n) involved, thus-

$$\bar{X} = \frac{X_1 + X_2 + X_3, \ldots\ldots\ldots\ldots\ldots X_n}{n} \text{ Or } \frac{\Sigma X_n}{n}$$

Where, X_1, X_2, X_3,…….X_n are the observations and n is the total number of observations involved.

b) Standard Deviation (S.D.)

Standard deviation or the standard range of observations is the positive square root of the average of the sum of the square of deviations of all observations from their mean. Symbolically S.D. for small samples (less than 30 replicates) was computed as-

$$SD = \pm \sqrt{\frac{(\bar{X}-X_1)^2 + (\bar{X}-X_2)^2 + (\bar{X}-X_3)^2 + \ldots\ldots\ldots\ldots\ldots (\bar{X}-X_n)^2}{n-1}}$$

Where, $\bar{X}$ = mean of observations

X_1, X_2, X_3,….X_n = observations

n = number of observations involved

c) t-test of significance

This test is applied to test the difference observed between two sample means. In the present study, it was applied to test the significances of the difference between two sample means.

The following formula was used to compute t-values and compared with table values of 't' at their specific degrees of freedom ($DF = n_1+n_2-2$). The difference between two samples was considered as significant if calculated t-value exceeded the table value.

$$t = \frac{\text{Difference of two sample means}}{\text{Standard error of the difference}}$$

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{(SD_1)^2}{n_1} - \frac{(SD_2)^2}{n_2}}}$$

Where, $\bar{X}_1$ and $\bar{X}_2$ = Arithmetic means of sample 1 and sample 2, respectively

SD_1 and SD_2 = Standard deviation of respective sample mean

n_1 and n_2= number of observations of respective sample mean

d) Least Significant Difference (L.S.D.)

The value limiting the ultimate random deviation is called as the least significant difference. It is abbreviated to L.S.D. If the empirical difference (d) is equal or greater than LSD, the difference is significant. If empirical difference d is less than LSD, the difference is non significant. The least significant difference was applied for unifactor and bifactor experiments and computed as follows-

(i) Unifactor experiment

The procedure of manual computation of unifactor LSD is given as follows–

Step-1. Construction of data table for 5 treatments and 3 replicates. The data were compiled such that, each treatment occupied a column and their replicates were arranged in rows (Table A).

Construction of data Table A for unifactor LSD of 5 treatments and 3 replicates–

Rows (Replicates)	Columns (Treatments)					Total of rows (Replicates) ($\sum X$)	Squares of total of rows (X^2)
	T_0	T_1	T_2	T_3	T_4		
R_1	2.09	2.78	0.89	0.94	0.75	7.45	55.50
R_2	3.73	3.59	1.07	0.58	0.32	9.29	86.30
R_3	3.15	1.46	1.76	1.33	1.15	8.85	78.32
Total of column ($\sum Y$)	8.97	7.83	3.72	2.85	2.22	25.59	55.5+...78.32 W_r = 220.12
Squares of totals of columns $(\sum Y)^2$	80.46	61.31	13.84	8.12	4.93	80.46+.........4.93 W_Y = 168.66	

Sum of squares of total of column ($\sum^2$) = $(2.09)^2+\ldots(3.15)^2=28.20$; $(2.78)^2+\ldots(1.46)^2=22.75$; $(0.89)^2+\ldots(1.76)^2=5.04$; $(0.94)^2\ldots(1.33)^2=2.99$; $(0.75)^2+\ldots(1.15)^2=1.98$

$$W_Z = 28.20+22.75+5.04+2.99+1.98 = 60.96$$

Step-2. Correction Factor (C.F.)

$$CF = \frac{(\text{Grand Total})^2}{t.r} = \frac{(25.59)^2}{5\times 3} = 43.66$$

Where, t = number of treatments, r = number of replicates, W_X = grand total

Step-3. Total sum of squares (SSQT) - this is the sum of squares of all the values in the table less the correction factor

$$SSQT = W_Z - CF = 60.96 - 43.66 = 17.30$$

Step-4. Sum of Squares of Treatments (SSQt)

$$SSQt = \frac{W_Y}{r} - CF = \frac{168.66}{3} - 43.66 = 12.56$$

Step-5. Sum of Squares of rows or Replicates (SSQr)

$$SSQr = \frac{W_r}{t} - CF = \frac{220.12}{5} - 43.66 = 0.364$$

Step-6. Sum of Squares of Error (SSQE)

$$SSQE = SSQT - (SSQt + SSQr)$$

$$= 17.30 - (12.56 + 0.364) = 4.376$$

Step-7. Estimated Variance of Error (MSE)

$$MSE = \frac{SSQE}{(t-1)(r-1)} = \frac{4.376}{(4)\times(2)} = 0.547$$

Step-8. ANOVA table for df, SS, MSS and corresponding F-value were prepared. The L.S.D. was calculated if F-value was significant. The non-significant L.S.D. values are marked as NS in data tables.

Source of variation	df	SS	MSS	F value	Significance
Replicates	2	0.364	0.182		
Treatment	4	12.56	3.141	5.742	* *
Error	8	4.376	0.547		

Step-9. Least Significant Difference (L.S.D.), based on ordinary t-test

$$\text{LSD at 5\% level} = \sqrt{\frac{2\text{MSE}}{r}} \ . \ (\text{t value at 5\% level})$$

$$= \sqrt{\frac{2 \times 1.094}{3}} \times 3.84 \ = 1.39$$

$$\text{LSD at 1\% level} = \sqrt{\frac{2\text{MSE}}{r}} \ . \ (\text{t value at 1\% level})$$

$$= \sqrt{\frac{2 \times 1.094}{3}} \times 7.01 \ = 2.03$$

(ii) Bifactor experiments

Step-1. Construction of data table for a total 25 treatments (5 regimes of watering 'A' x 5 growth stages in days 'B') and 3 replicates. The data were complied such that each treatment occupied a row and their replicates were arranged in column (Table B).

Step-2. Correction Factor (CF)

$$CF = \frac{(W_X)^2}{(t_A \times t_B).r} = \frac{(1511.22)^2}{(5 \times 5).3} = 30450.48$$

Where, t_A = number of treatments of factor A

t_b = number of treatments of factor B (days)

Table B. Construction of data table for a total 25 treatments (5 concentrations of NPK 'A'×5 growth stages in days 'B') and 3 replicates.

Treatments	Replicates			Total of Treatments ($\sum$)	Squares of totals of treatments $(\sum)^2$	Sum squares of totals of treatments ($\sum^2$)
	R_1	R_2	R_3			
W_1d_7	11.34	18.90	15.12	11.34 + ... 15.12 = 45.36	$(45.36)^2$ = 2057.53	$(11.34)^2$ + ... $(15.12)^2$ = 714.42
W_1d_{14}	13.01	21.69	17.35	13.01 + ... 17.35 = 52.05	$(52.05)^2$ = 2,709.20	$(13.01)^2$ + ... $(17.35)^2$ = 940 70
W_1d_{21}	12.59	20.98	16.78	12.59 + ... 16.78 = 50.34	$(50.34)^2$ = 2,534.12	$(12.59)^2$ + ... $(16.78)^2$ = 879 90
W_1d_{28}	11.15	18.59	14.87	11.15 + ... 14.87 = 44.61	$(44.61)^2$ = 1,990.05	$(11.15)^2$ + ... $(14.87)^2$ = 690 99
W_1d_{35}	8.96	14.94	11.95	8.96 + ... 11.95 = 35.85	$(35.85)^2$ = 1,285.22	$(8.96)^2$ + ... $(11.95)^2$ = 446.26
W_2d_7	16.03	26.71	21.37	16.03 + ... 21.37 = 64.11	$(21.37)^2$ = 4,110.09	$(16.03)^2$ + ... $(21.37)^2$ = 1427.12
W_2d_{14}	14.41	24.01	19.21	14.41 + ... 19.21 = 57.63	$(57.63)^2$ = 3,321.22	$(14.41)^2$ + ... $(19.21)^2$ = 1153.20
W_2d_{21}	13.77	22.95	18.36	13.77 + ... 18.36 = 55.08	$(55.08)^2$ = 3,033.81	$(13.77)^2$ + ... $(18.36)^2$ = 1053.41
W_2d_{28}	11.42	19.04	15.23	11.42 + ... 15.23 = 45.69	$(45.69)^2$ = 2,087.58	$(11.42)^2$ + ... $(15.23)^2$ = 724.85
W_2d_{35}	9.51	15.85	12.68	9.51 + ... 12.68 = 38.04	$(38.04)^2$ = 1,447.04	$(9.51)^2$ + ... $(12.68)^2$ = 502.45
W_3d_7	19.94	33.24	26.59	19.94 + ... 26.59 = 79.77	$(79.77)^2$ = 6,363.25	$(19.94)^2$ + ... $(26.59)^2$ = 2209.46
W_3d_{14}	21.55	35.91	28.73	21.55 + ... 28.73 = 86.19	$(86.19)^2$ = 7,428.72	$(21.55)^2$ + ... $(28.73)^2$ = 2579.42
W_3d_{21}	15.81	26.35	21.08	15.81 + ... 21.08 = 63.24	$(63.24)^2$ = 3,999.30	$(15.81)^2$ + ... $(21.08)^2$ = 1388.63
W_3d_{28}	11.81	19.68	15.74	11.81 + ... 13.45 = 47.22	$(47.22)^2$ = 2,229.73	$(11.81)^2$ + ... $(15.74)^2$ = 774.21
W_3d_{35}	10.09	16.81	13.45	10.09 + ... 13.45 = 40.35	$(40.35)^2$ = 1,628.12	$(10.09)^2$ + ... $(13.45)^2$ = 565.32
W_4d_7	22.71	37.85	30.28	22.71 + ... 30.28 = 90.84	$(90.84)^2$ = 8,251.91	$(22.71)^2$ + ... $(30.28)^2$ = 2865.25
W_4d_{14}	24.14	40.23	32.18	24.14 + ... 32.18 = 96.54	$(96.54)^2$ = 9,319.97	$(24.14)^2$ + ... $(32.18)^2$ = 3236.10
W_4d_{21}	17.59	29.31	23.45	17.59 + ... 23.45 = 70.35	$(70.35)^2$ = 4,949.12	$(17.59)^2$ + ... $(23.45)^2$ = 1718.45
W_4d_{28}	12.28	20.46	16.37	12.28 + ... 16.37 = 49.11	$(49.11)^2$ = 2,411.79	$(12.28)^2$ + ... $(16.37)^2$ = 837.43
W_4d_{35}	10.39	17.31	13.85	10.39 + ... 13.85 = 41.55	$(41.55)^2$ = 1,726.40	$(10.39)^2$ + ... $(13.85)^2$ = 599.45
W_5d_7	23.06	38.43	30.74	23.06 + ... 30.74 = 92.22	$(92.22)^2$ = 8,504.53	$(23.06)^2$ + ... $(30.74)^2$ = 2952.96
W_5d_{14}	25.06	41.76	33.41	25.06 + ... 33.41 = 100.23	$(100.23)^2$ = 10,046.05	$(25.06)^2$ + ... $(33.41)^2$ = 3488.2
W_5d_{21}	18.26	30.44	24.35	18.26 + ...24.35 = 73.05	$(73.05)^2$ = 5,336.30	$(18.26)^2$ + ... $(24.35)^2$ = 1352.83
W_5d_{28}	12.47	20.79	16.63	12.47 + ... 16.63 = 49.89	$(49.89)^2$ = 2,489.01	$(12.47)^2$ + ... $(16.63)^2$ = 864.24
W_5d_{35}	10.48	17.46	13.97	10.48 + ...13.97 = 41.91	$(41.91)^2$ = 1,756.45	$(10.48)^2$ + ... $(13.97)^2$ = 609.88
Total of replicates ($\sum$)	11.34 + ... 10.48 = 377.81	18.90 + ... 17.46 = 629.68	15.12 + ... 13.97 = 503.74	11.34 + ... 13.97 or 45.36 + ...41.91 = W_X = 1511.22	$(45.36)^2$ + ... $(41.91)^2$ = W_t or 101016.51	714.42 + ... 609.88 = W or 35075.18
Squares of totals of replicates ($\sum^2$)	$(377.81)^2$ = 142740.40	$(629.68)^2$ = 396496.90	$(503.74)^2$ = 253753.99	$(377.81)^2$ + ... $(503.74)^2$ = W_r or 792991.20		

r = number of replicates

W_x = grand total

Step-3. Total Sum of Squares (SSQT)

This is the sum of squares of all the values in the table less the correction factor

$$SSQT = W_z - CF = 35075.18 - 30450.48 = 4624.70$$

Step-4. Sum of Squares of Treatments (SSQt)

$$SSQt = \frac{W_Y}{r} - CF = \frac{101016.51}{3} - 30450.48 = 3221.69$$

Where, r = number of replicates or rows

Step-5. Sum of Squares of rows or Replicates (SSQr)

$$SSQr = \frac{W_r}{t_A \times t_B} - CF = \frac{792981.21}{5 \times 5} - 30450.48 = 1268.77$$

Where, t_A = number of treatments of factor **A** (water treatment)

t_B = number of treatments of factor **B** (days)

Step-6. Sum of Squares of Error (SSQE)

$$SSQE = SSQT - SSQt - SSQr$$

$$= 4624.70 - 3221.69 - 1268.77 = 134.24$$

Step-7. Determining sums for main effects (water treatments and days) and their *interaction (Table C).*

Table C. Determining sums for main effects (water treatment and days) and their interaction.

Days (B)	Watering intervals (A)					Sums (B)	Squares of totals of rows $(B)^2$
	W_1	W_2	W_3	W_4	W_5		
Day-7	45.36	52.05	50.34	44.61	35.85	228.21	52079.80
Day-14	64.11	57.63	55.08	45.69	38.04	260.55	67886.30
Day-21	79.77	86.19	63.24	47.22	40.35	316.77	100343.23
Day-28	90.84	96.54	70.35	49.11	41.55	348.39	121375.59
Day-35	92.22	100.23	73.05	49.89	41.91	357.30	127663.29
Sums (A)	*372.30*	*392.64*	*312.06*	*236.52*	*197.7*	*1511.22*	52079.80 +..... *127663.29* = $\sum B^2$ *or* 469348.21
Squares of totals of columns $(A)^2$	138607.29	154166.17	97381.44	55941.71	39085.29	138607.29 +.... 39085.29 = $\sum A^2$ or 485181.90	

Step-8. Sum of squares of main effects (water treatments and days) and their interaction.

Sum square of treatment **A**

$$SSQt_A = \frac{\Sigma A^2}{t_B . r} - CF = \frac{485181.90}{5 \times 3} - 30450.48 = 1894.98$$

Sum of square of days **B**

$$SSQt_B = \frac{\Sigma B^2}{t_A . r} - CF = \frac{469348.21}{5 \times 3} - 30450.48 = 839.40$$

Sum of squares of interaction **AB**

$$SSQt_{AB} = SSQt - (SSQt_A + SSQt_B)$$

$$= 3221.69 - (1894.98 + 839.40) = 487.31$$

Step-9. Estimated variance of error (MSE) of main effects and their interaction.

$$MSE_A = \frac{SSQt_A}{(t_A - 1)} = \frac{1894.98}{5-1} = 437.74$$

$$MSE_B = \frac{SSQt_B}{(t_B - 1)} = \frac{839.40}{5-1} = 209.85$$

$$MSE_{AB} = \frac{SSQt_{AB}}{(t_A - 1)(t_B - 1)} = \frac{487.31}{(5-1)(5-1)} = 30.46$$

$$MSE\ (error) = \frac{SSQE}{(t_A . t_B - 1)(r - 1)} = \frac{134.24}{24 \times 2} = 2.69$$

Step-10. ANOVA table for df, SS, MSS and corresponding F-value were prepared. The L.S.D. was calculated if F-value was significant. The non-significant L.S.D. values are marked as NS in data tables.

Source of variation	df	SS	MSS	F value	Significance
Replicates	2	10.285	5.143		
Water Stress	4	1894.98	473.75	176.115	**
Time Interval	4	839.40	209.85	78.011	**
Interaction	16	487.31	30.46	11.323	**
Error	48	134.24	2.69		

Step-11. Least Significant Difference based on ordinary t-test (LSD)

$$LSD_A = \sqrt{\frac{2MSE\ (error)}{t_B \cdot r}} \cdot (\text{t value at 5\% level})$$

$$= \sqrt{\frac{2 \times 2.69}{5 \times 3}} \times 2.00 = 1.20$$

$$LSD_B = \sqrt{\frac{2MSE\ (error)}{t_A \cdot r}} \cdot (\text{t value at 5\% level})$$

$$= \sqrt{\frac{2 \times 2.69}{5 \times 3}} \times 2.00 = 1.20$$

$$LSD_{AB}\ (\text{interaction}) = \sqrt{\frac{2MSE\ (error)}{r}} \cdot (\text{t value at 5\% level})$$

$$= \sqrt{\frac{2 \times 2.69}{3}} \times 2.00 = 2.68$$

$$LSD_A = \sqrt{\frac{2MSE\ (error)}{t_B \cdot r}} \cdot (\text{t value at 1\% level})$$

$$= \sqrt{\frac{2 \times 2.69}{5 \times 3}} \times 2.66 = 1.59$$

$$LSD_B = \sqrt{\frac{2MSE\ (error)}{t_A \cdot r}} \cdot (\text{t value at 1\% level})$$

$$= \sqrt{\frac{2 \times 2.69}{5 \times 3} \times 2.66} = 1.59$$

$$LSD_{AB} \text{ (interaction)} = \sqrt{\frac{2MSE \text{ (error)}}{r}} \text{ . (t value at 1\% level)}$$

$$= \sqrt{\frac{2 \times 2.69}{3} \times 2.66} = 3.56$$

e) Correlation coefficient (r)

The correlation coefficient is a statistical measure. It indicates both nature and degree of relationship between measurable characteristics, say growth stage (days) and height of plant. The correlation coefficient is denoted by symbol 'r'. The value of 'r' varies between -1 to +1. The value closer to unit number 1 shows greater degree of relationship and sign (+ or -) indicate positive or negative relationship between the parameters. When 'r'< 0.3, the correlation between variables is said to be weak; when r = 0.3-0.7, medium; and when 'r' > 0.7, strong.

One example of the procedure of computing the correlation coefficient 'r' between the growth stages (in days) and plant height of *Mirabilis jalapa* (as shown in Table - D) is given below–

Step-1. Construction of data table.

Table D–The pairs of characters were arranged as follows-

S.No. of paires of observations	Growth stage in days (X)	Plant height (Y)	X^2	Y^2	XY
1	7	15.12	49	228.6	105.84
2	14	21.37	196	456.78	299.18
3	21	26.59	441	707.03	558.39
4	28	30.28	784	916.88	847.84
5	35	30.74	1225	944.95	1075.9
Total (∑)	**∑X= 105**	**∑Y= 124.09**	**$\sum X^2$= 2695**	**$\sum Y^2$= 3254.24**	**∑XY= 2887.15**

Step-2. Computation of the following-

a) Sum of X-values $\sum X$

b) Sum of Y-values $\sum Y$

c) Squares of each X-value and their sum $\sum X^2$

d) Squares of each Y-value and their sum $\sum Y^2$

e) Product of each pair (X and Y) and their sum $\sum XY$

Step-3. Computation of 'r' values as follows-

$$r = +/- = \frac{n(\Sigma XY) - (\Sigma X)(\Sigma Y)}{\sqrt{[n(\Sigma X^2) - (\Sigma X)^2][n(\Sigma Y^2) - (\Sigma Y)^2]}}$$

$$r = +/- = \frac{5(2887.15) - (105)(124.09)}{\sqrt{[5(2695) - (105)^2][5(3254.24) - (124.09)^2]}} = 0.968$$

Where, N = number of pairs of observations.

f) Test of significance of 'r'

The 't' test of significance of the correlation coefficient was applied to determine whether the relationship between the two characters viz., water treatment and plant height is really significant or merely due to chance. It was computed as follows-

$$t_0 = r\sqrt{\frac{N-2}{1-r^2}}$$

Where, r = correlation coefficient, N = number of pairs of observations, t_0 = observed value of 't'

If observed 't' value is equal to or exceeds the table value of 't', the relationship is said to be significant. The table values of 't' at 5% level and 1% level of significance were obtained from the table of t-values.

g) Coefficient of determination (d)

It is derivative of correlation coefficient and denoted by 'd'. When expressed in percentage, it shows percent dependence of a dependable variant on independent variable. It is determined as follows-

$$d = (r)^2$$

$$\text{or, } \%d = 100\,(r)^2$$

Where, r is correlation coefficient, d is degree of dependence or determination and %d is coefficient of determination expressed in percentage.

h) Linear regression

Correlation coefficient elucidates the nature and degree of relationship between two characteristics. Due to such correlation, when variation in one variable bring in accompanying changes in the other, it enables us to predict the values of one variable from the knowledge of other viz., for a given water treatment the expected height of plant can be predicted by linear regression line or equation. The regression line, best fitting the observations was obtained by the following formula-

$$\hat{Y} = a + bX$$

$$b = \frac{N\Sigma XY - (\Sigma X)\,(\Sigma Y)}{N\Sigma X^2 - (\Sigma X)^2}$$

$$a = \hat{Y} - bX$$

Where, $\hat{Y}$ (Y-hat) indicates the predicted values of y for a given value of X. X, Y are observations of two characters (water treatment and plant height), a and b are constants. X and Y are arithmetic means of all observations of the respective variables (X and Y).

Meteorological Data

Meteorological data on temperature, rainfall and relative humidity were collected from metrological section of Department of Physics, Aligarh Muslim University, Aligarh and are presented in Figure 3.

The season in north Indian planes (Uttar Pradesh) is divisible into three distinct seasons as winter, summer and monsoon. The winter season starts from October to February, summer from March to Mid-June and monsoon from Mid-June to September. The summer season is hot and dry and characterized by very low humidity and high speed of winds locally called as "*Loo*". The winds blow almost with the speed of gale from 10 o'clock to 4 o'clock from mid April to May. The hottest summer period is from May to mid June. The monsoon season is characterized by high temperature, very high humidity and excessive downpour up to 250 to 300mm. In the winter season light and occasional rain is recorded. In the year 2006, some unusual excessive rain was recorded in the months of February and March. The humidity in winter season also remained high (Figure 3B).

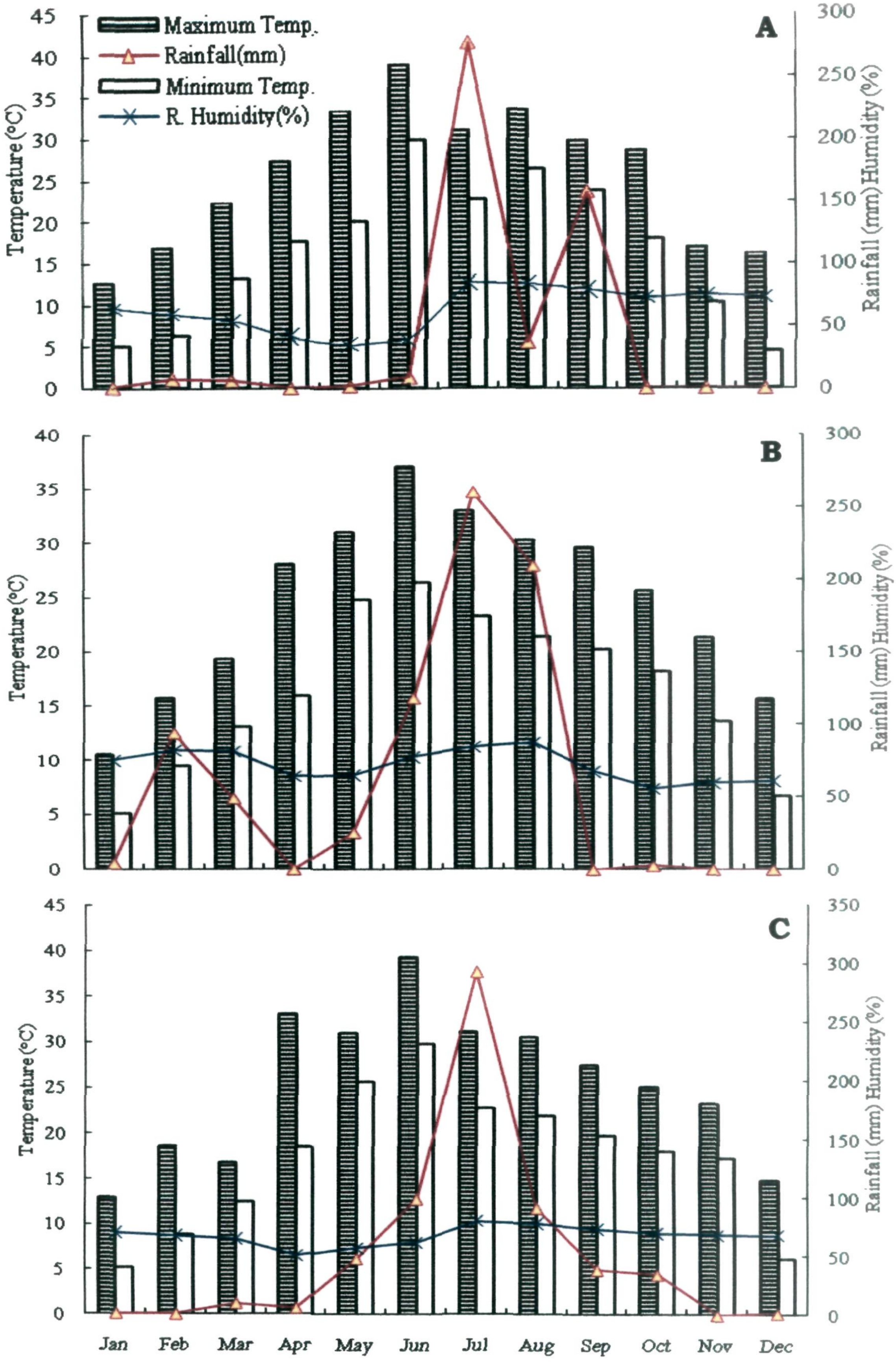


Figure 3: Monthly average of temperature, humidity and rainfall in the year 2005 (A), 2006 (B) and 2007 (C), respectively (Coursey: Department of Physics, AMU, Aligarh).

Annexure

Methods and Techniques of Soil Analysis

a) Soil organic matter

Soil organic matter was determined following Walkley and Black 1934 and described below–

Reagents Used-

1. Standard 1N Potassium dichromate: 49.04g of (AR grade) $K_2Cr_2O_7$ was dissolved in distilled water and volume made up to 1L
2. 0.5 N Ferrous ammonium sulphate: 196g of the AR grade hydrated crystalline salt ($FeSO_4.(NH_4)_2SO_4.6H_2O$) was dissolved in 1 liter of distilled water containing 20ml of conc. H_2SO_4. This was prepared fresh for each set of sample
3. Diphenylamine indicator: 0.5g diphenylamine was dissolved in a mixture of 20ml of distilled water and 100ml of conc. H_2SO_4
4. Concentrated sulphuric acid containing 1.25% silver sulphate (Ag_2SO_4)
5. 85% Ortho-phosphoric acid (H_3PO_4)

One gram dried soil was taken in 500ml conical flask. 10 ml of 1N $K_2Cr_2O_7$ was pipette in the flask and swirled a little. Then 20ml of H_2SO_4 (containing 1.25% silver sulphate) was added and swirled again 2-3 times. The flask was allowed to stand for 30min. The content was diluted by adding 200ml of distilled water in a flask, 10ml of ortho-phosphoric acid and 1ml of diphenylamine indicator was added in it. The colour of solution turned bluish-purple. This content was titrated with 0.5N ferrous ammonium sulphate solution until the colour changed from blue-violet to green and end point was recorded. Simultaneously, a blank was run without soil sample and reading was also noted down and expressed as blank. From these readings, organic carbon in the soil was determined by the following formulae–

$$\text{Percent organic carbon in soil (\%)} = \frac{N\,(B - C)}{S} \times 0.003 \times 100 \text{ or } 0.15\,(B - C)$$

$$\text{Total organic matter} = \%\ \text{organic carbon} \times 1.724$$

Where, N = normality of ferrous ammonium sulphate solution (0.05)

B = volume of ferrous ammonium sulphate used in the titration of blank

C = volume of ferrous ammonium sulphate used in the titration of soil sample

S = weight of soil sample (1g)

b) Soil moisture

The soil moisture was measured by gravimetric method. 100 g of soil was sampled from top 30cm layer with the help of auger. The soil samples were kept in polythene bags, brought to laboratory and weighed for fresh weight. The soil samples were then oven dried at 105^0C for 48hrs and weighed for dry weight. Soil moisture content calculated as–

$$\text{Per cent soil moisture (\%)} = \frac{\text{Fresh weigh - Dry weight}}{\text{Dry weight}} \times 100$$

c) Soil nitrogen

Soil nitrogen was estimated by Alkaline permanganate method (Subbiah and Asija 1956). In 1L Kjeldahl flask 20g of soil sample was taken, 20 ml of DDW water, 100ml $KMnO_4$ (0.32%) and 100ml NaOH (2.5%) solutions were added. Before subjecting to Kjeldahl assembly, 1ml liquid paraffin and a few glass beads were added to prevent frothing and bumping, respectively. The content was distilled in Kjeldahl assembly at a steady rate and the liberated ammonia was collected in a 250ml conical flask containing 200ml of boric acid solution (mixed with methyl red and bromocresol green indicators). The pink colour of the boric acid solution turned green with the absorption of ammonia. 100ml of distillate was titrated against 0.02N H_2SO_4. Blank titration was also carried out, simultaneously. The N_2 content was calculated by the formula-

$$X = R - b$$

$$N_2 = X \times 0.02 \times 1/20 \times 0.04 \times 2.24 \times 10^6 \text{ kg ha}^{-1}$$

$$\text{Or,} \quad N_2 = X \times 31.36 \text{ kg ha}^{-1}$$

Where, R = Volume of 0.02N H_2SO_4 required for titration

b = Volume of 0.02N H_2SO4 required for blank titration (without soil)

X = Actual volume of 0.02N H_2SO_4 used in titration

The values have also been present in mg N_2 /kg soil by converting the values with the following formula of Gao *et al.* (2003)-

$$1 \text{ kg ha}^{-1} N_2 = \frac{1000 \times 1000}{2.24 \times 1000000} \text{ mg kg}^{-1} \text{ soil}$$

d) **Soil phosphorus**

Reagent used-

1. Olsen's Reagent: 1.5M sodium bicarbonate pH 8.5
2. Dickman and Bray's reagent: 15g of ammonium molybdate in 300ml of warm water (60°C), cooled and filtered. To this, 400ml of 10N HCL was added and volume was made up to 1L.

3. **Stannous Chloride** Stock Solution: 10g of stannous chloride (crystalline) be **dissolved in 26ml of concentration HCL by warming and stored in an amber-coloured bottle. This is the 40% $SnCl_2$ stock solution.**

The available phosphorus in soil was extracted following Olsen's method (Olsen *et al.* 1954). To 2.5g of soil was taken in 100ml conical flask, a little amount of Darco G60 was added followed by 50ml of Olsen's reagent. A blank was run without soil. The flasks were shaken for 30 minutes on a shaker and the contents were filtrated immediately through filter paper (Whatman No. 1).

From the filtrate, phosphorus was estimated colorimetrically by excess acid procedure of Dickman and Bray (1940). 5ml of soil extract (obtained through Olsen's method) was pipette into a 25ml volumetric flask. To this Dickman and Bray's reagent was added drop by drop with constant shaking till the effervescence due to CO_2 evolution ceased. The neck of the flask was washed down with distilled water and the volume was made approximately 22ml. Then 1ml of the diluted stannous chloride solution (from freshly prepared 40% $SnCl_2$ stock solution) was added and volume was made up to 25ml. the intensity of blue colour was measured at 660nm using a spectrophotometer just after 10 minutes. The concentration of P was determined from the standard curve. Available phosphorous content was calculated as follows-

$$\text{Available P } (\mu g) = R \times [50/2.5] \times [25/5] = R \times 100\ \mu g\ g^{-1}\ (\text{ppm})$$

$$(\text{ppm} \times 2.24 = \text{Kg ha}^{-1})$$

Where, R = μg P in the aliquot (obtained from the standard curve).

The standard Curve for Phosphorus was prepared by dissolving 0.438g potassium dihydrogen orthosphate (KH_2PO_4) in 500ml distilled water. 25ml 7N H_2SO_4 solution was added and the final volume was made up to 1L with distilled water.

From this solution 0.1, 0.2, 0.3, 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0 ml was taken in different test tubes. The solution in test tubes was diluted to 5ml with distilled water. In each tube, 1.0 ml molybdic acid and 0.4 ml 1-amino-2-naphthol-4-sulphonic acid was added. After 5min optical density was read at 730 nm on a spectrophotometer. A blank was also run with each set. Standard curve was prepared using different dilution of potassium dihydrogen orthophosphate solution versus optical density. The amount of phosphorous was determined with the standard curve.

e) Soil potassium

Available potassium (exchangeable and water soluble) was determined from neutral normal ammonium acetate extract of soil (Jackson 1973). For this 5g soil was shaken with 25ml neutral normal ammonium acetate (2N acetic acid glacial+2N ammonium hydroxide in 1:1, pH 7.0) for 5-10 minutes and filtered immediately. Potassium concentration in extract was determined by flame photometer.

Results

RESULTS

In the present work, autecological life cycles, survivorship of two invasive species namely, *Mirabilis jalapa* and *Ruellia tuberosa* have been studied with special reference to the impact of varying water regimes. The community invaded by both these species differed in structure, light factors and root exudates of some component species. It was therefore, considered fitting to study few attributes of the invaded community with reference to a non-invaded patch, impact of variable light and root exudates on the growth of selected invasive species. The result is presented here using the figures of analyzed data. The tables of detailed data are annexed at the end of bibliography (Tables 3 to 93).

Community structure of the selected sites

The community dynamics of the selected invaded field had been studied at 4 Sites. The selected field consisted of 4 large patches. Each patch was named as sites 1-4. **Site 1** was invaded by *Mirabilis jalapa*, **Site 2** and **Site 3** by *Ruellia tuberosa*. **Site 4** was not invaded by either of these two species and termed as un-invaded site. The community structure of all four sites was studied at monthly intervals as described below.

Site 1 (invaded by *Mirabilis jalapa*)

Among 15 species at Site 1, *Mirabilis jalapa, Achyranthes aspera, Scoparia dulcis* and *Chenopodium album* were the highly abundant species as evident from the analyzed data (Figure 4A). The *Alternanthera pungenus* and *Rumex dentatus* were least abundant species (Figure 4A). Besides *Mirabilis jalapa*, the next most frequent species at Site 1 was *Parthenium hysterophorus* and *Rumex dentatus* the least frequent one (Figure 4B). The relative density of *Mirabilis jalapa* at Site 1 was 39.09 followed by *Parthenium*

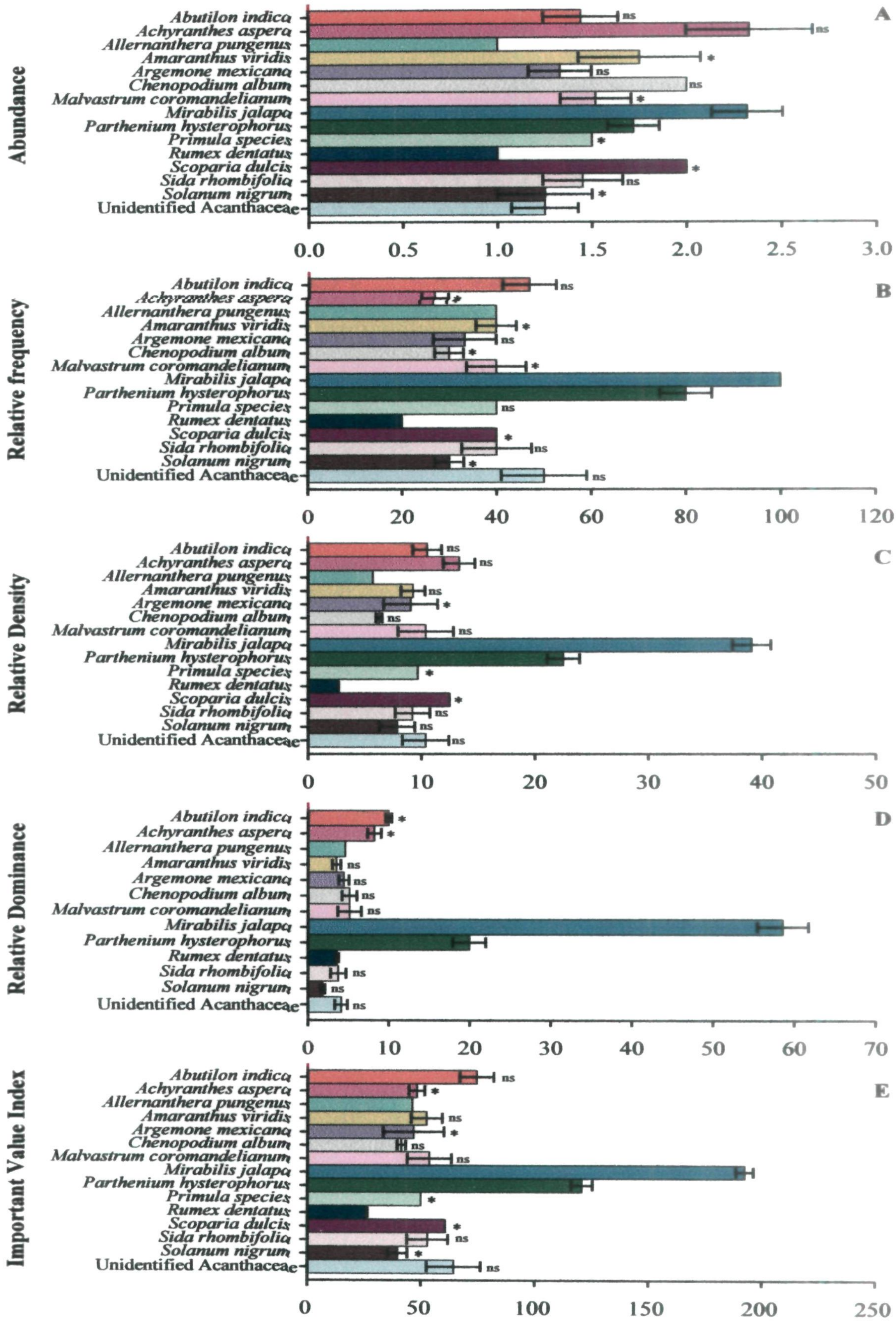


Figure 4. Community structure of Site 1 invaded by *Mirabilis jalapa* (Data in annexed Tables 3 to 7).

hysterophorus (22.52). The *Rumex dentatus* had least relative density (Figure 4C). The relative dominance of *Parthenium* species was next to *Mirabilis jalapa* (Figure 4D).

Site 2 and 3 (Invaded by *Ruellia tuberosa*)

Site 2 and 3 were invaded by *Ruellia tuberosa*. But the relative growth performance of *Ruellia tuberosa* varied at both the sites. The abundance of *R. tuberosa* was higher at Site 3 than at Site 2 (Figure 5A and 6A). At Site 2, *R. tuberosa* was associated with 6 species and at Site 3 with 17 species. Among total 7 species of Site 2, *Capparis sepiaria* and *Aerva* species had special appearance, which were absent at Site 3 having a total of 18 species (Figure 5 and 6). The relative frequency of *C. sepiaria* was highest at Site 2 (Figure 5B). At Site 3, the relative frequency and relative density of most of co-occurring species were far lower than the invasive *R. tuberosa* (Figure 6B, 6C). The relative density of *R. tuberosa* at Site 2 and Site 3 did not differ significantly (Figure 5C and 6C). The relative density of co-dominant *Capparis sepiaria* was highest among 6 species co-occurring with *Ruellia* species at Site 2 (Figure 5C). The unidentified Acanthaceae member (apparently resembling with *R. tuberosa*) had almost equal density at both the Sites 2 and 3 (Figure 5C and 6C). At Site 2, the relative dominance and IVI of *R. tuberosa* were highest followed by *Capparis sepiaria, Achyranthes aspera, Malvastrum coromandelianum* and unidentified Acanthaceae member (Figure 5D, 5E). The relative dominance of *R. tuberosa* at Site 3 was relatively lesser than at Site 2 (Figure 5D and 6D). The unidentified Acanthaceae member and *Achyranthes aspera* were co-dominant with *R. tuberosa* at Site 3 (Figure 6D). The IVI of *R. tuberosa* was statistically similar (non-significant difference) at Site 2 and 3 (Figure 5E and 6E). But the IVI of co-occurring native species at Site 3 varied from 25.23 to 64.27 (Figure 6E).

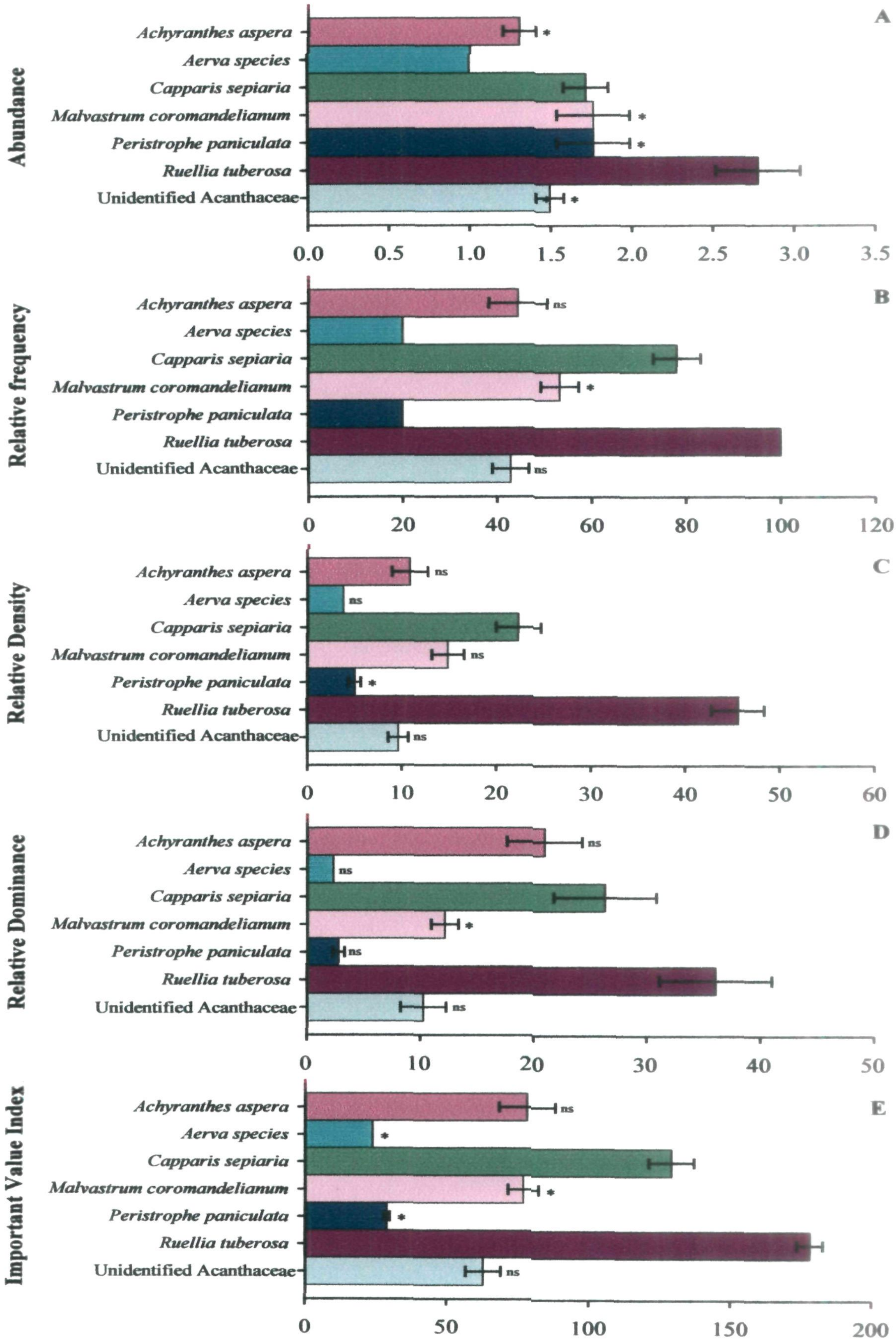


Figure 5. Community structure of Site 2 invaded by *Ruellia tuberosa* (Data in annexed Tables 8 to 12).

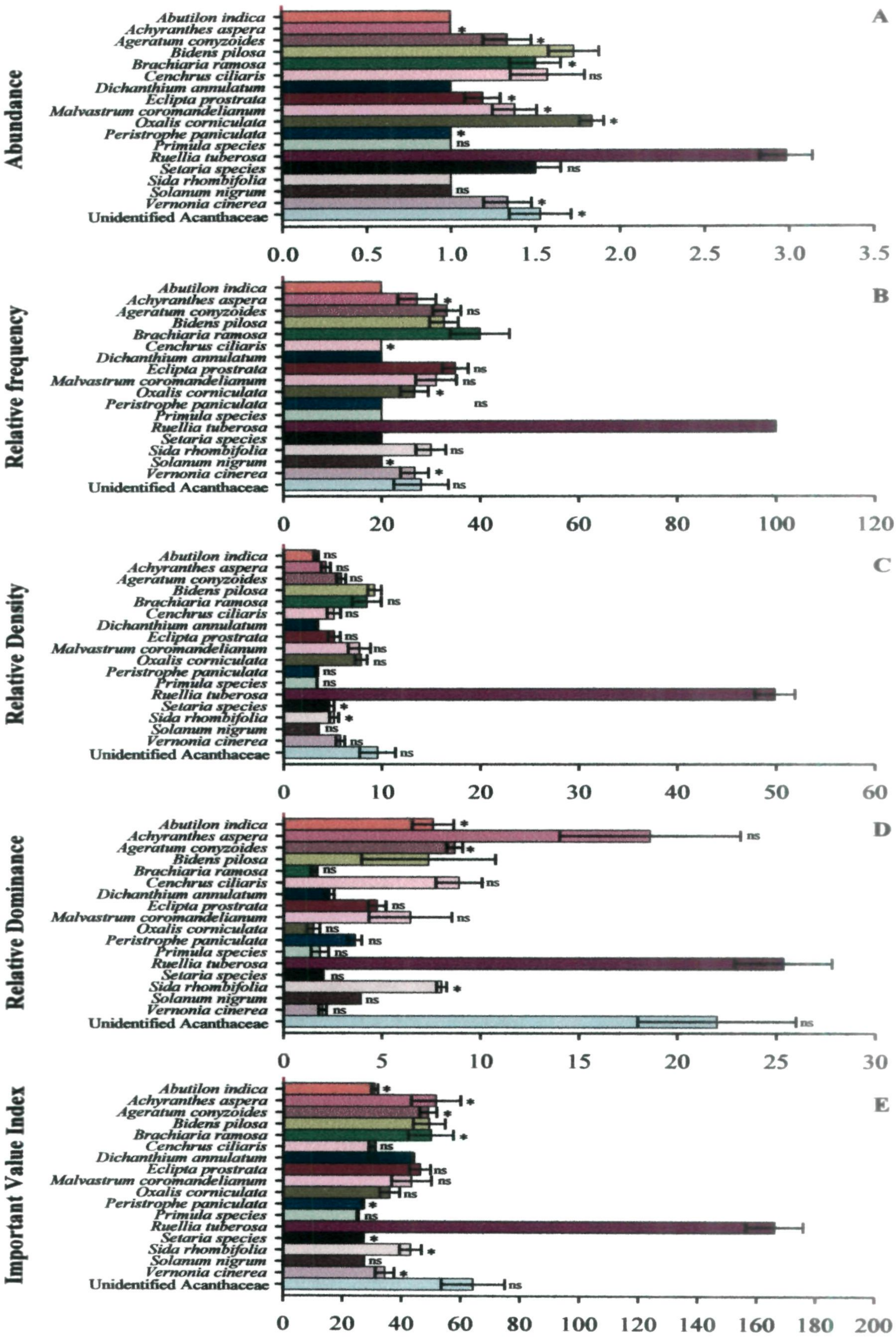


Figure 6. Community structure of Site 3 invaded by *Ruellia tuberosa* (Data in annexed Tables 13 to 17).

Site 4 (Non-invaded site)

The Site 4 was not invaded by both the selected species. The total number of component native species was 25 (Figure 7). Among these species, the unidentified Acanthaceae member occurred only for 4 months (April to July) with lesser relative density (Figure 7C). The *Malvastrum coromandelianum* was highly abundant with high relative frequency and density throughout the year (Figure 7B). But, the relative dominance of *Amaranthus viridis* was higher as its stem was thicker than *M. coromandelianum* and thickest among all 25 component native species of Site 4 (Figure 7D). The IVI of 4 native species namely *A. viridis*, *M. coromandelianum* and *Chenopodium album* was highest at Site 4 (Figure 7E).

Community indices

The Margalef's richness index at Site 3 and Site 4 were high followed by Site 1 (Figure 8A). As evident from the Simpson's dominance index, the non-invaded Site 4 was heterogeneous and Site 2 invaded by *Ruellia tuberosa* was highly homogenous having high dominance index (Figure 8B). The invasion of both the selected species also reduced species diversity at Site 1, 2 and 3 as evident from Shannon's diversity index. The diversity index at Site 2 was least (Figure 8C). As evident from higher Hill's evenness index, the non-invaded community (Site 4) was much more even than Site 3 invaded by *Ruellia tuberosa* (Figure 8D). There was a seasonal impact on the community indices at all four sites. The community indices in summer months had greater variations at all four selected sites. A comparative glance on Margalef's and Simpson's indices show that the site richness (Margalef's index) was high at non-invaded Site 4 from April to July indicating a greater diversity, high patchiness (low evenness index) and minimized dominance (Simpson's index) of any one native species (Figure 9B). In

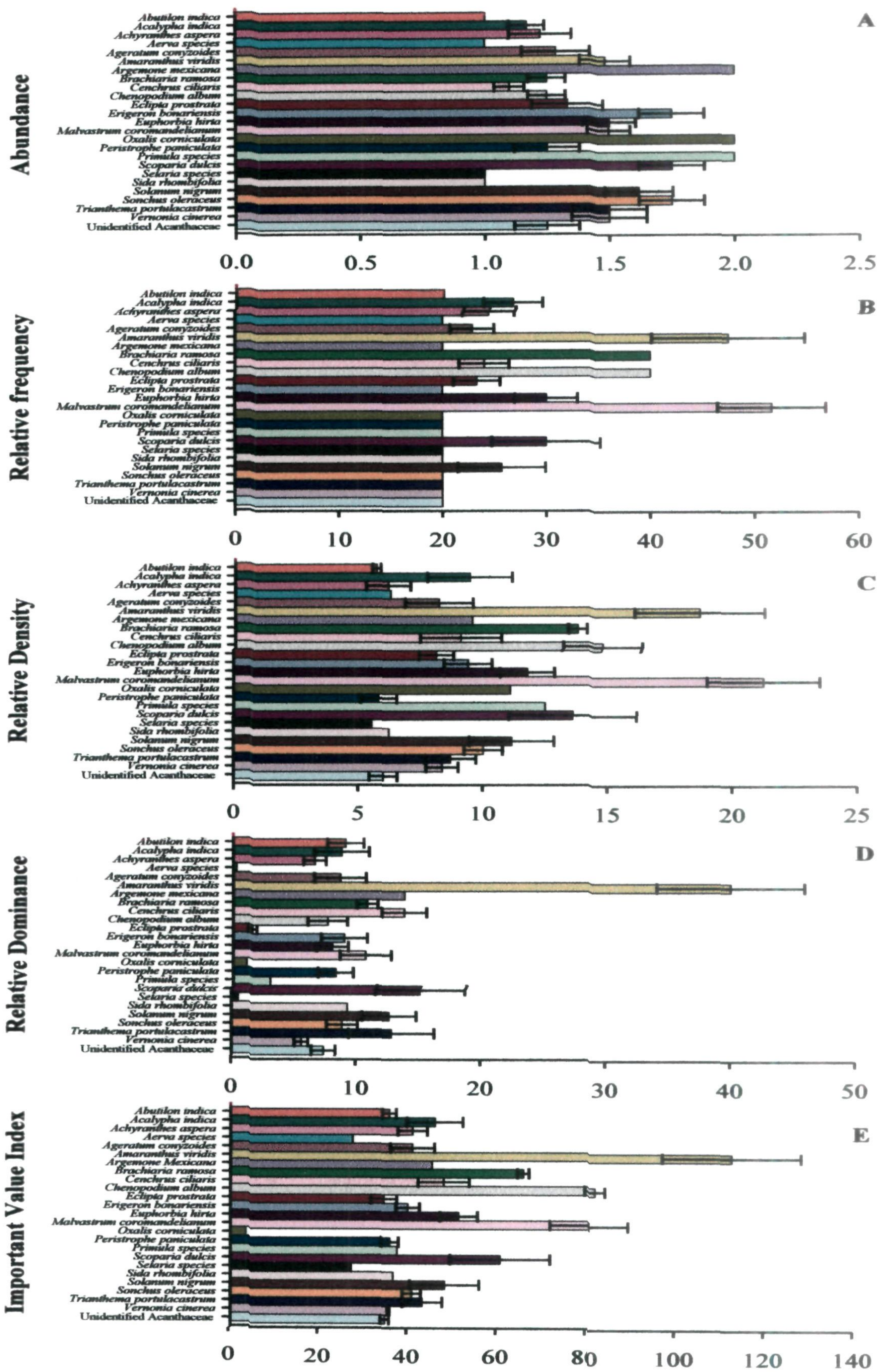


Figure 7. Community structure of Site 4 not invaded by *Mirabilis jalapa* and *Ruellia tuberosa* (Data in annexed Tables 18 to 22).

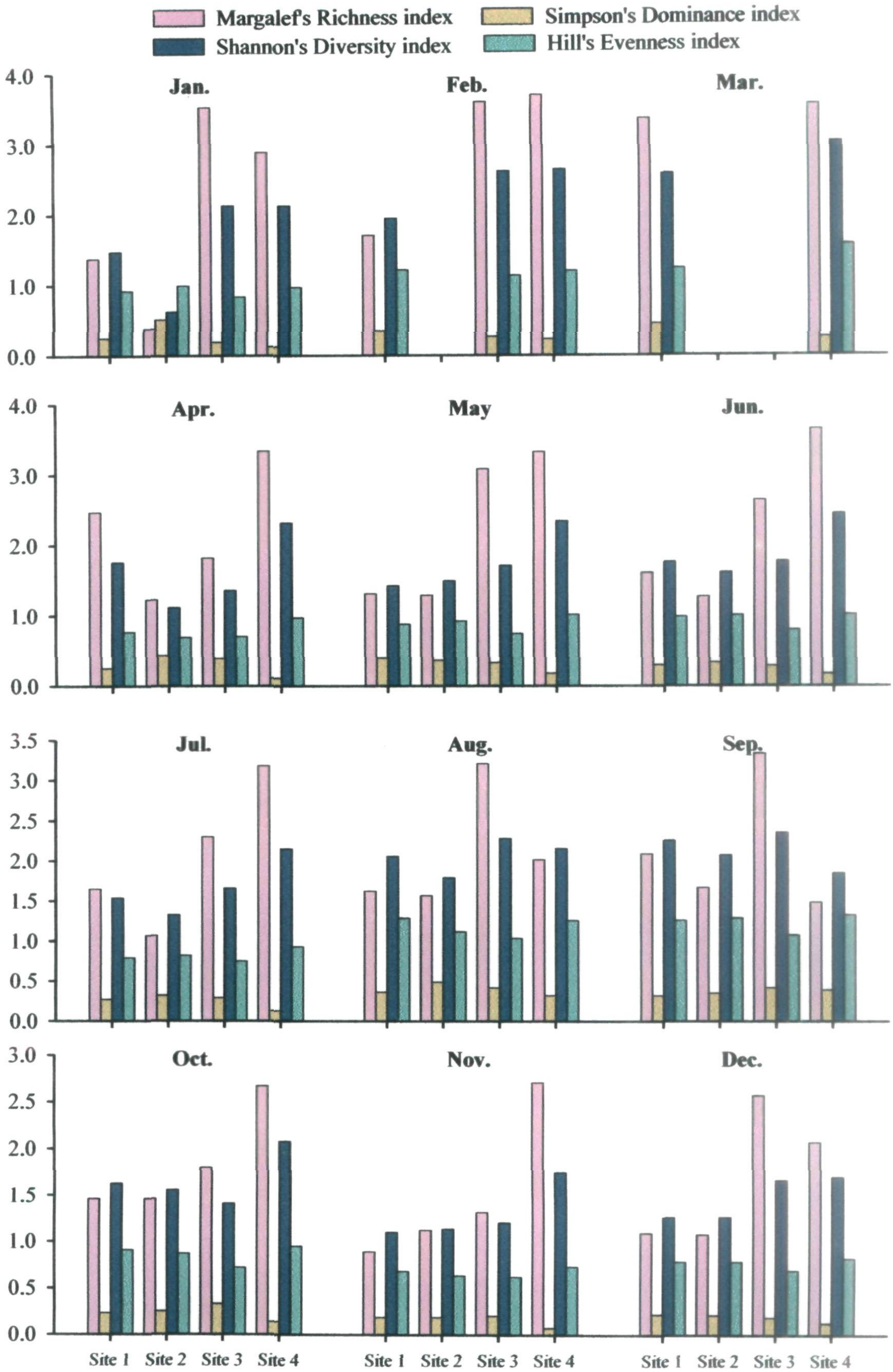


Figure 8. Histograms showing community indices of all 4 selected sites in varying months. (Data annexed in Table 23).

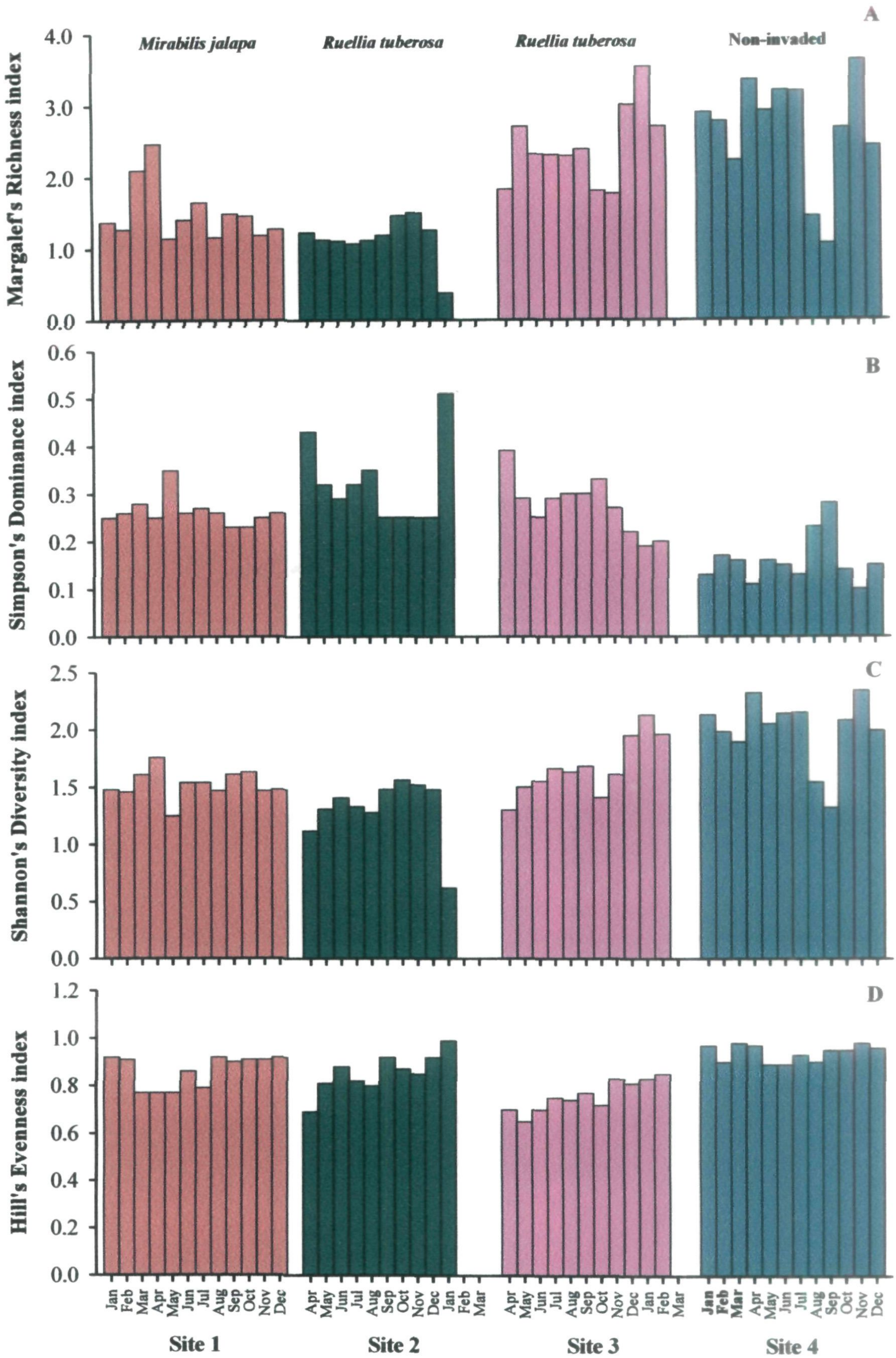


Figure 9. Community histograms showing four community indices at four selecected sites in varying months (Data in annexed Table 23).

winter season, the richness, diversity and evenness indices remained more higher at Site 4 and least at Site 3 (Figure 9A and D).

Growth, life cycle and survivorship curves of *Mirabilis jalapa*

Studies on the selected vegetative and reproductive growth parameters of *Mirabilis jalapa* were conducted from the beginning of their life cycle (last week of December) to the end of the life cycle (first week of January of the following year).

a) Plant growth

The stem of *Mirabilis jalapa* at Site 1 elongated exponentially until the month of July and thereafter slowed down (Figure 10A). The leaf number increased up to September-October (Figure 10B). The leaf size (area) of *M. jalapa* at Site 1 was larger from January to March and July to December (Figure 10B). In summer season (April to June), the average leaf area reduced marginally due to defoliation of older leaves of larger size (Figure 10C). Due to higher leaf number and larger leaf size between July and December, the total leaf area per plant was also higher than in summer months. During vegetative growth, there was a consistent increase in leaf number and leaf area from January to May (Figure 10C). The extent of vegetative growth of pot cultivated individuals was far lesser than those growing in field (Figure 10, 11 and 12).

The relative water content (RWC) in the leaves of cultivated and wild individuals did not show any significant variations within a given month (Figure 11A). Chlorophyll-a and total chlorophyll content was relatively higher in cultivated plants of *Mirabilis jalapa* as compared to those growing at Site 1 (Figure 11B and D). But in the month of August, the chlorophyll content (a, b and total) was higher in the field individuals (Site 1). The chlorophyll-b content in *Mirabilis jalapa* at Site 1 was higher in winter months during October to December (Figure 11C).

Plate 2

A – Seedlings of *Mirabilis jalapa* 7 days after germination in pot in February.

B – Seedlings of *Mirabilis jalapa* (⇨) germinated at Site 1 in January.

C – Reproductive growth phase (budding and flowering) of *Mirabilis jalapa* grown in pots with adequate moisture for the study of life cycle.

D – Reproductive growth phase (budding, flowering and fruiting) of *Mirabilis jalapa* at Site 1 in September.

Bars equal to 100mm.

Plate 2

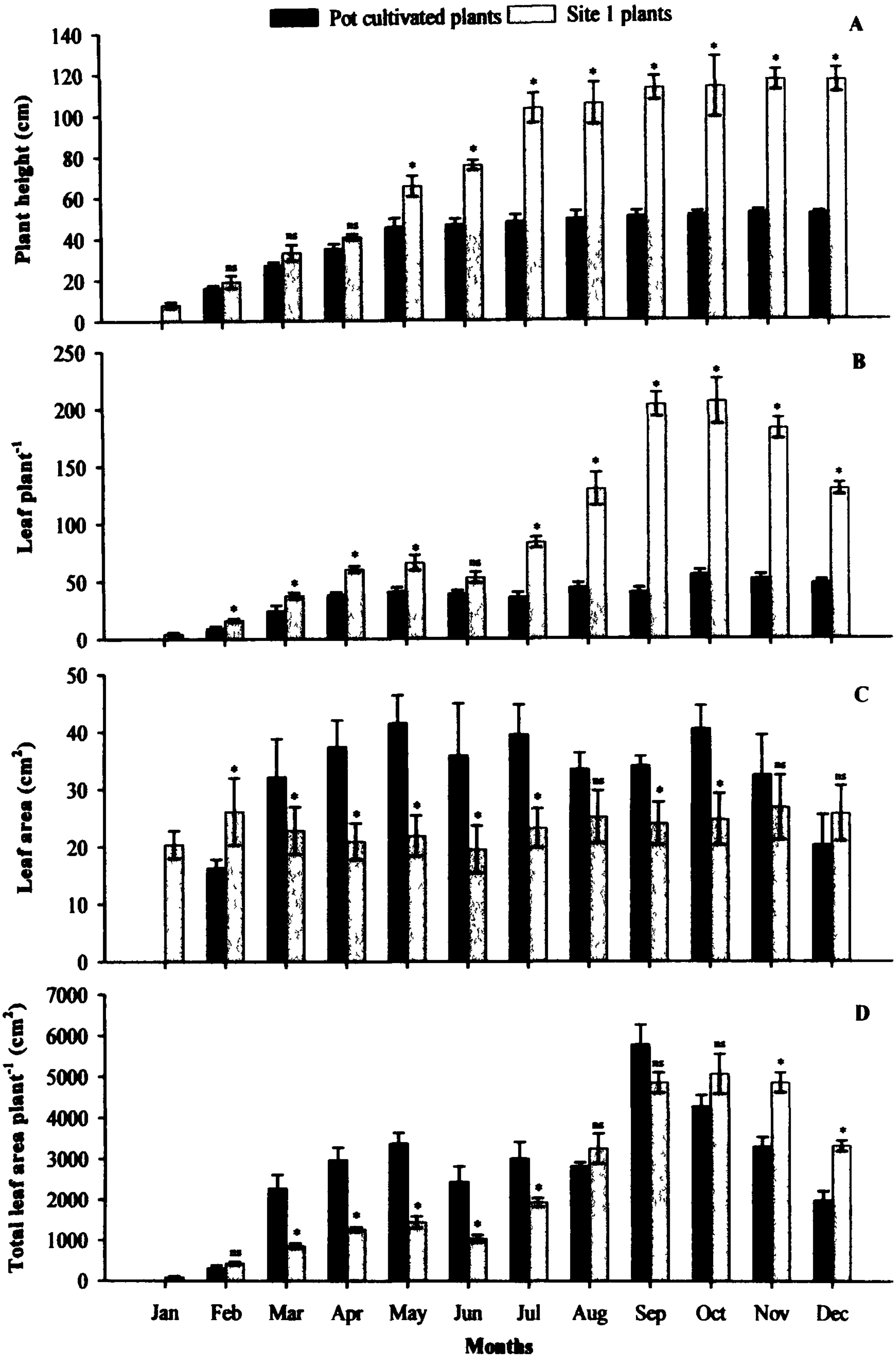


Figure 10. A comparative account of the growth (plant height, leaf plant^{-1}, Leaf area, total leaf area plant^{-1}) of *Mirabilis jalapa* grown in pots and at invaded Site 1 (Data in annexed Table 24). (Bars show mean±SE and significance of difference between sample means); *significant at 5% level and ns as non-significant.

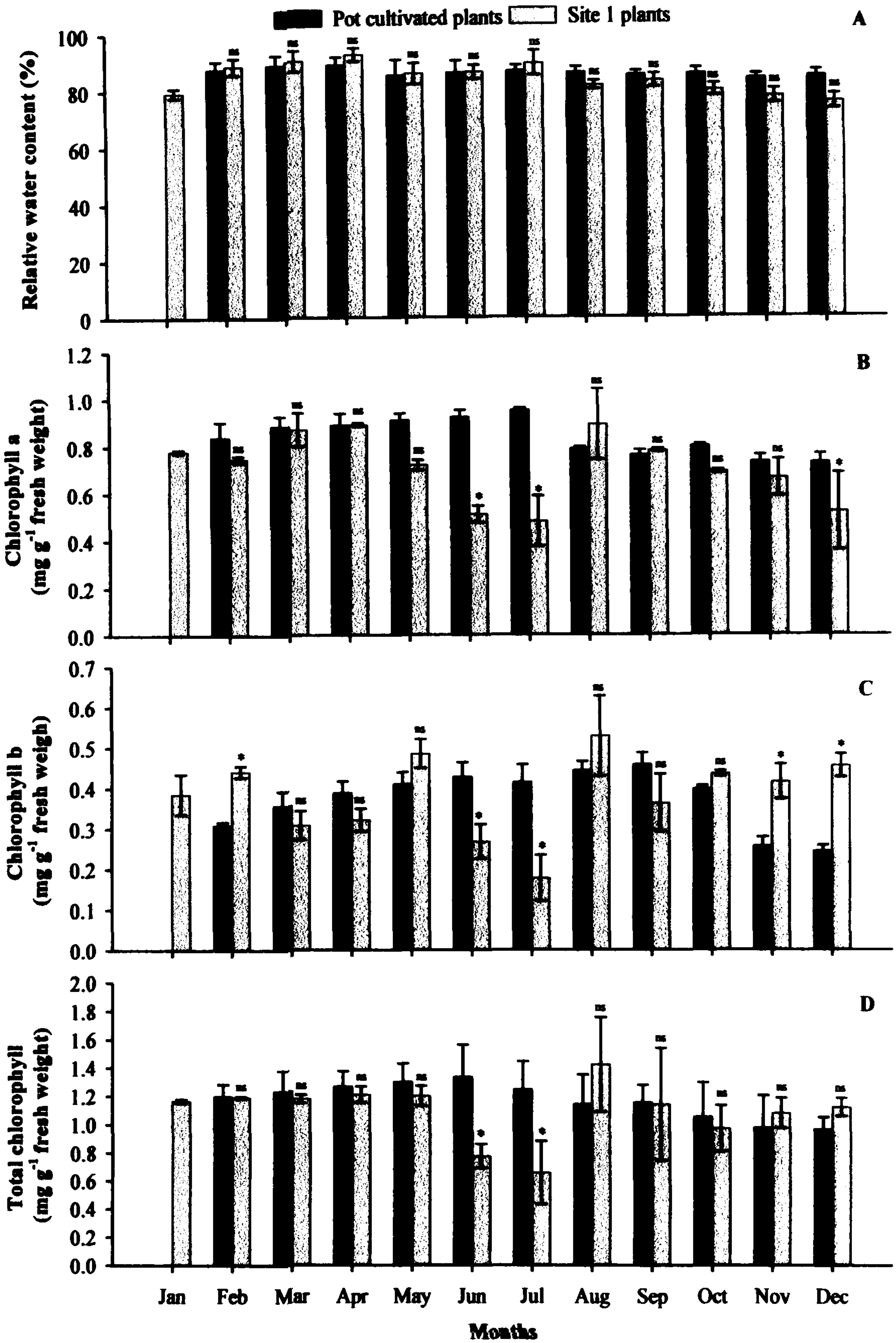


Figure 11. A comparative account of the biochemical leaf traits (relative water content and chlorophyll content) of *Mirabilis jalapa* grown in pots and at invaded Site 1 (Data in annexed Table 25). (Bars show mean±SE and significance of difference between sample means); *significant at 5% level and ns as non-significant.

The stomata number and abundance was studied in the leaves of 2nd or 3rd internode (without damaging the leaves) by obtaining impression of adaxial and abaxial leaf surfaces. The leaves emerged at the time of germination in the month of January and their number increased until April. The leaves of Ist flush defoliated between June and July and new set of leaves emerged between July and August. The leaves of 2nd flush of *Mirabilis jalapa* persisted till November and December (Figure 10) and had highest number in October. The stomata number and indices also had two patterns specific to each flush of leaf emergence. The Ist flush of leaves was between January to June and IInd between July to December.

In contrary to pot individuals, only few stomata were recorded on the adaxial surface of the leaves (1st flush) of *Mirabilis jalapa* at Site 1 during January to June (Figure 12A). The stomata in higher densities were usually present on the abaxial surface of the leaves of *M. jalapa* in pots. The stomatal density on abaxial surface of *M. jalapa* at Site 1 was relatively lesser during 2nd flush in winter months (December-March) and high during 1st flush from June to October as compared to cultivated individuals (Figure 12B). The stomatal index of cultivated *M. jalapa* was higher as compared to field individuals particularly during vegetative growth months (1st flush of leaf) extending from March to October (Figure 12C and D).

But ornamental value (in terms of flowering) of pot individuals was high as flowering started in the month of March and continued until December (Figure 13B). In pot cultivated individuals of *Mirabilis jalapa*, the fruit and seed setting was in two flushes, April to June and July to December (Figure 13B). But in the field, *M. jalapa* had a single reproductive phase from July to December (Figure 13B). Over all seed production was high in the field individuals albeit single and shorter reproductive phase (Figure 13D).

Plate 3

A and B – Leaf peal of adaxial surface of *Mirabilis jalapa* cultivated in pot showing absence of stomata (A) and of field individuals at Site 1 (B) showing presence of stomata in May.

C and D – Leaf peal of adaxial surface of leaf of *Mirabilis jalapa* cultivated in pot individuals (C) and field individuals at Site 1 (D) in July. In both the cases, the stomata are absent.

E and F – Low number of stomata on the abaxial leaf surface of *Mirabilis jalapa* in May in pots (E) and at Site 1 (F).

G and H – High number of stomata on the abaxial surface of *Mirabilis jalapa* in the July in pot cultivated (G) and field individuals (H).

I and J – V.S. of leaf showing variable proportions of leaf tissues (palisade, spongy parenchyma and vascular area) in pot cultivated individuals (I) and field individuals at Site 1 (J).

Bars equal to 50μ (A to H) and 100μ (I to J).

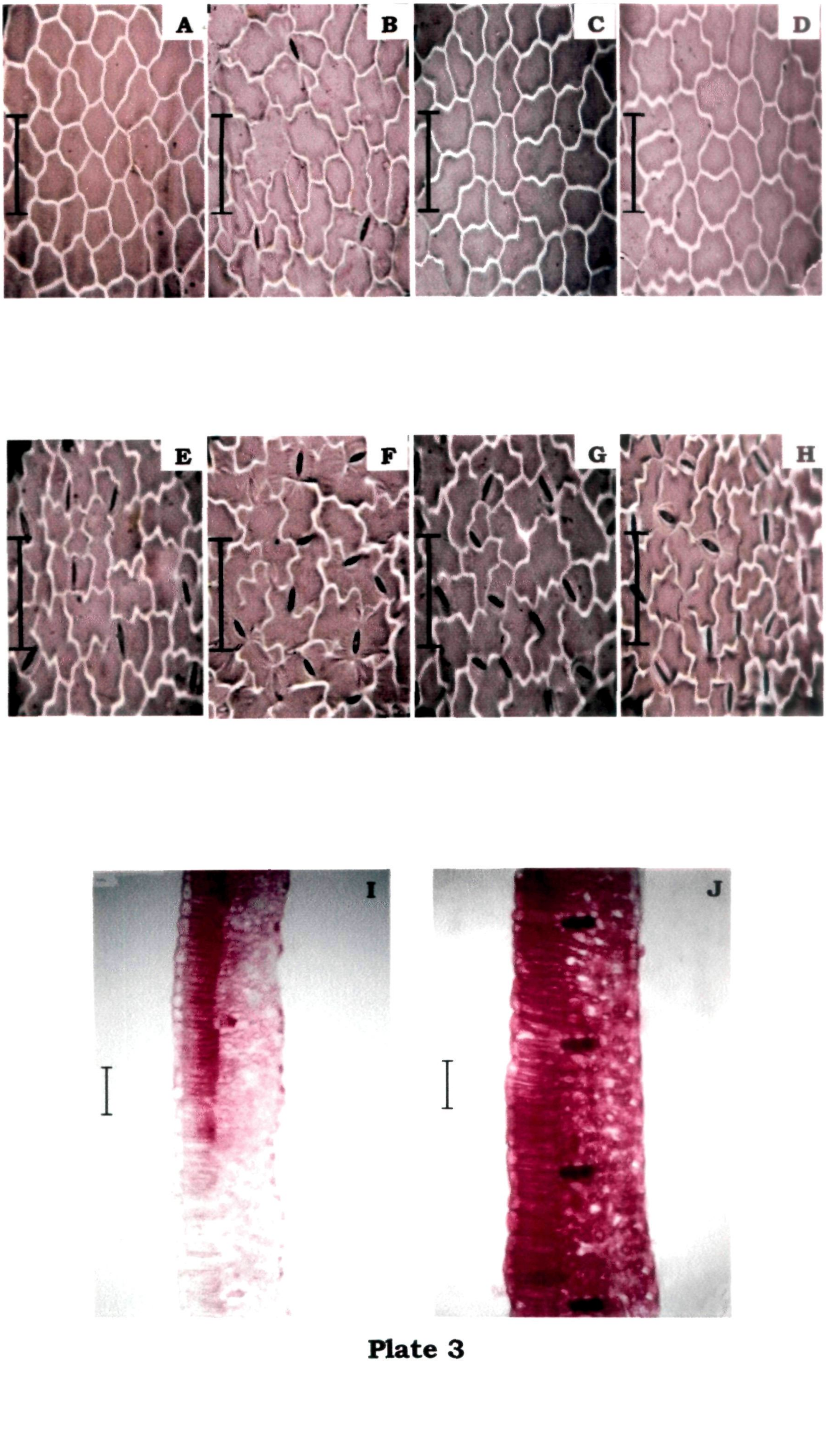


Plate 3

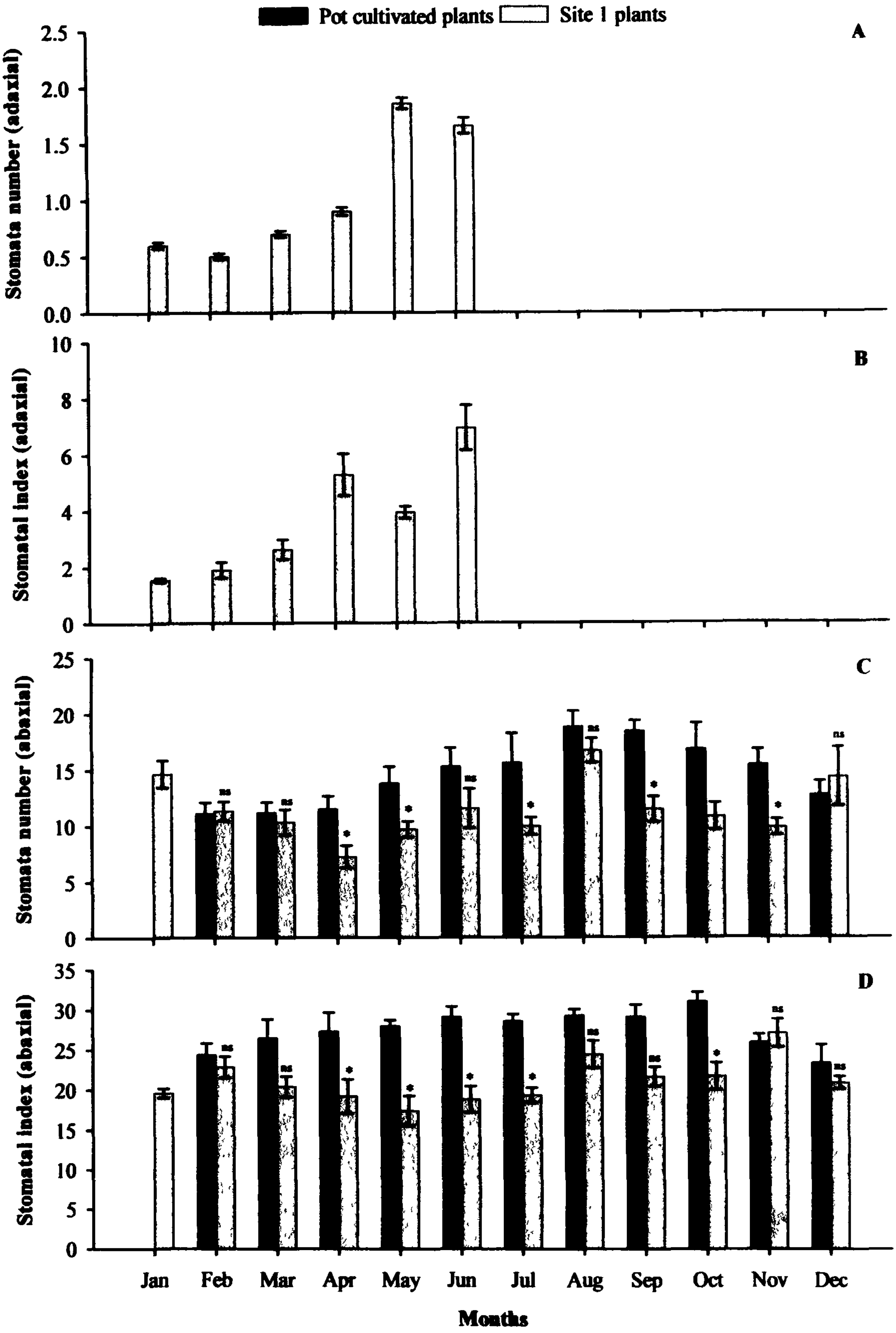


Figure 12. A comparative account of the micromorphological leaf traits (stomata number and indices) of *Mirabilis jalapa* grown in pots and at invaded Site 1 (Data in annexed Table 25).
(Bars show mean±SE and significance of difference between sample means);
*significant at 5% level and ns as non-significant.

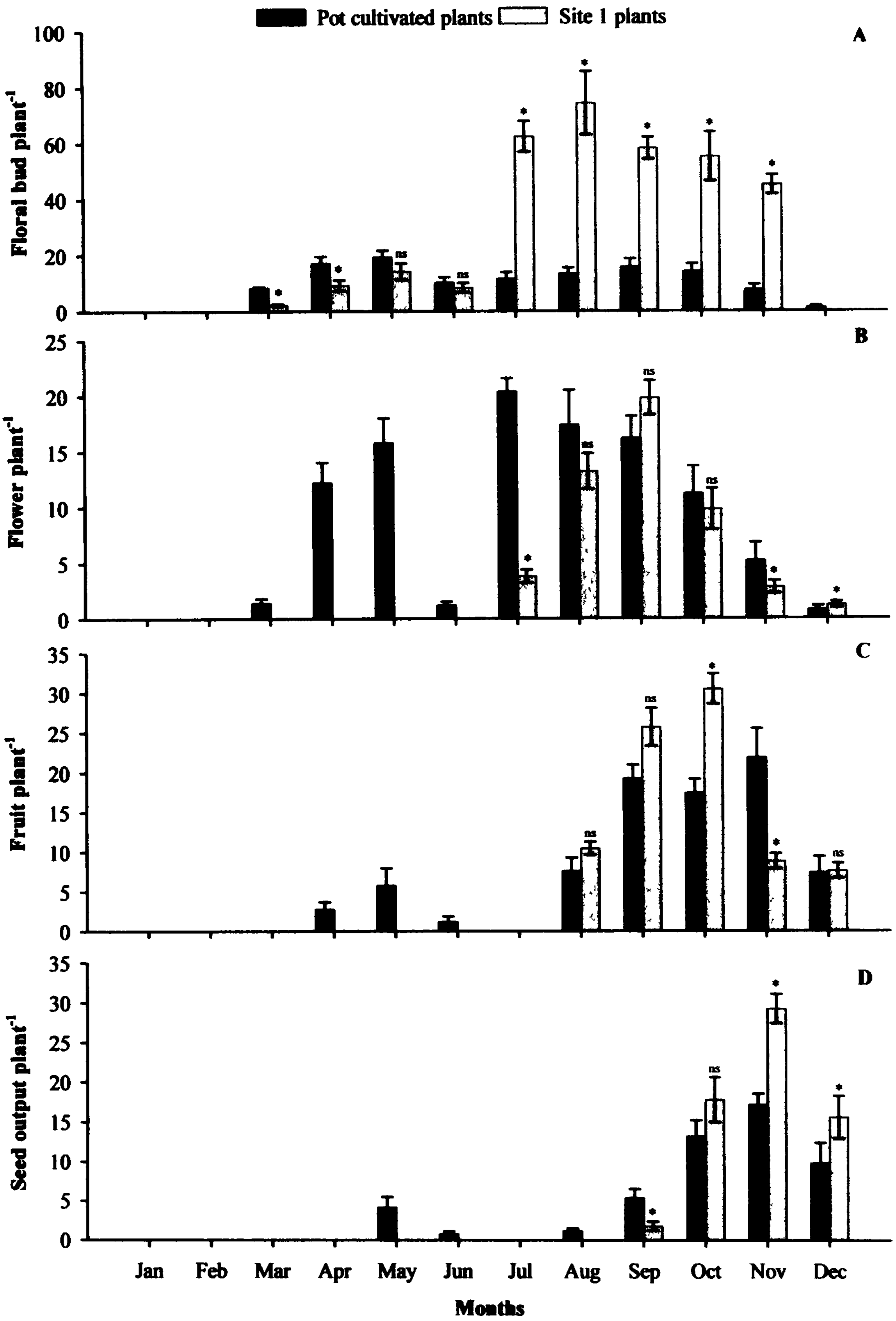


Figure 13. A comparative account of the reproductive growth (floral bud plant^{-1}, flower plant^{-1}, fruit plant^{-1} and seed output plant^{-1}) of *Mirabilis jalapa* grown in pots and at invaded Site 1 (Data in annexed Table 24).
(Bars show mean±SE and significance of difference between sample means);
*significant at 5% level and ns as non-significant.

Biological clock

The seeds of *Mirabilis jalapa* were collected in the month of September to December and sown in pots in the following January. Adequate moisture was maintained by daily watering after the germination. Five pots having one seedling of equal vigor were selected for the life cycle studies in pot. The growth parameters were recorded at monthly intervals from the last week of February.

The life cycle of *Mirabilis jalapa* in pots and field has been presented as monthly growth stages (Figure 14 and 15). The growth phases during one year life cycle of *M. jalapa* in pots is presented in Figure 14. Contrasting variations were recorded in growth phases of the plant under both the habitats. Some of the invasive characteristics of the species are evident from the variations in life cycle under both habitats. The seeds of *M. jalapa* germinated quickly at Site 1 without any apparent gap between 2 consecutive life cycles (Figure 15). But in the field, the total dormancy of seed could not be ascertained as the date of seed shedding in the field was not known. There was a single vegetative and reproductive growth phase in field individuals. During this phase *M. jalapa* had profused growth (Figure 15) in the field despite growing in association with 14 other component species (Figure 4). The pot cultivated individuals had one vegetative and two reproductive growth phases during one year life cycle (Figure 14). At Site 1, only few abortive floral buds were produced from March to May (Figure 15). The flowering phase was longer in pot cultivated plants but fruit and seed setting rates were far lesser than in the field individuals (Figure 15). The comparative account of the life cycles of pot and field individuals show that pot cultivated *M. jalapa* were superior in only ornamental values. Relatively smaller size plants of *M. jalapa* (grown in pots) produced larger number of flowers during both the flowering phases. But *M. jalapa* at its invaded Site 1 feasibly explored all available resources for its optimum vegetative growth and

Figure 14

Biological clock of *Mirabilis jalapa* cultivated in pot

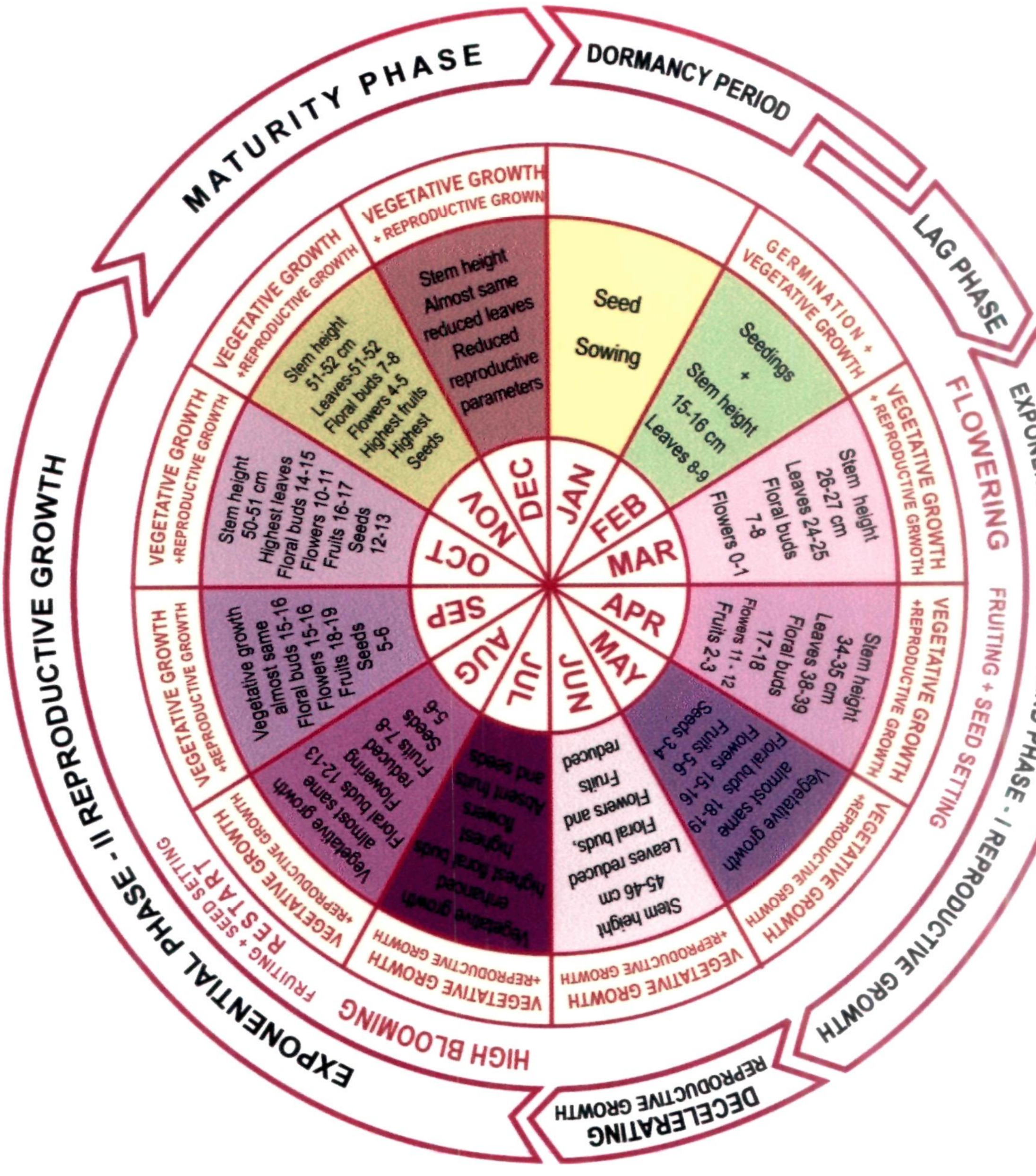
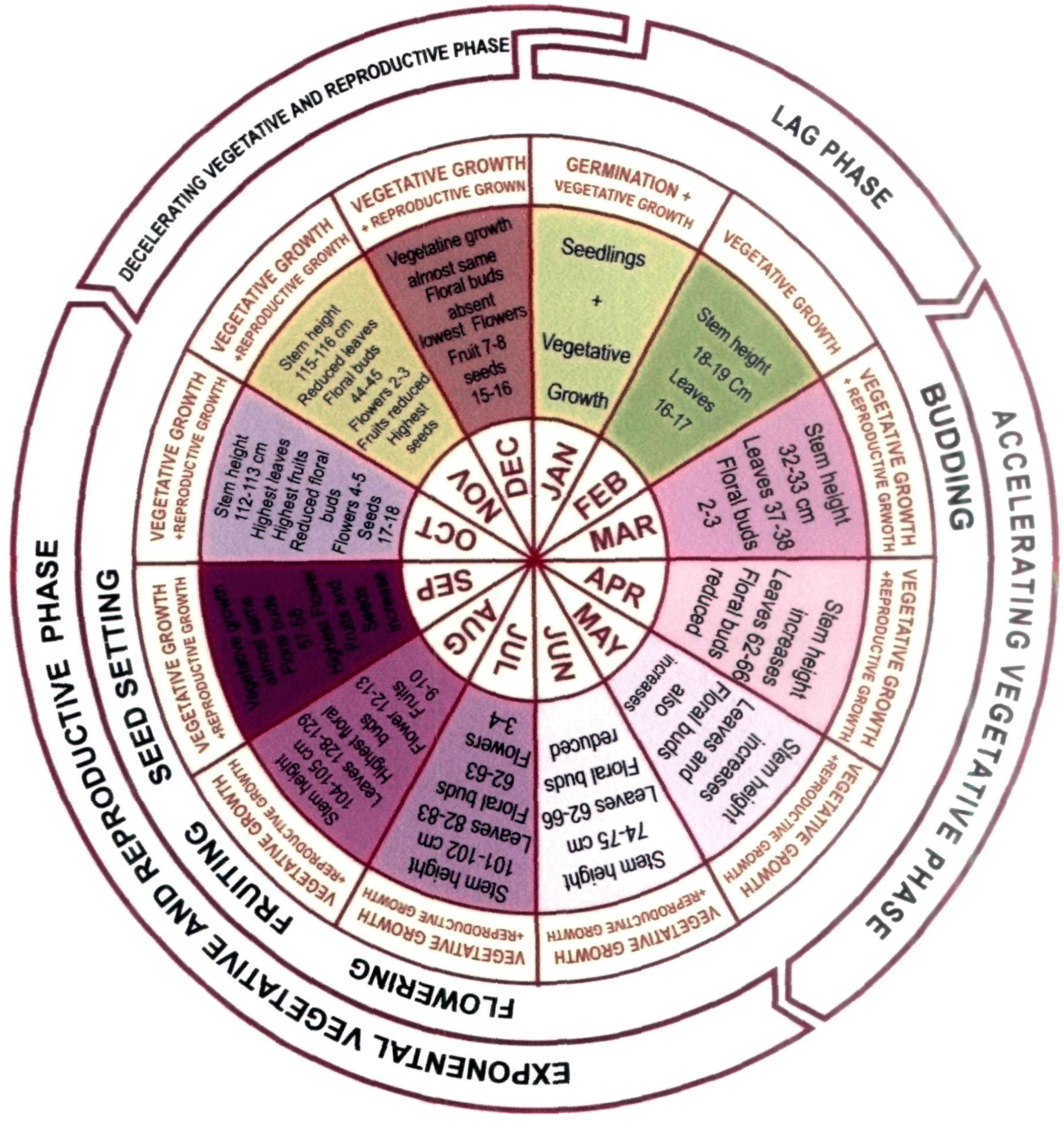


Figure 15

Biological clock of *Mirabilis jalapa* growing at Site 1



translocated to reproductive parts for larger number of seed setting during shorter reproductive phase (Figure 15) for its survival in the field. All these traits recorded in field individuals are invasive traits of *Mirabilis jalapa.*

c) Survival curve

The monthly trend of population growth (survival and mortality curves) of *Mirabilis jalapa* at Site 1 as standing and virtual survival and mortality curves (Figure 16). The standing population of *Mirabilis jalapa* in $1m^2$ has been projected out of number recorded in 25×25 cm^2 quadrat (triplicate) laid down during community study in 2005. This number includes the surviving individuals of previous year and those germinated between January to mid February as well as those germinated unusually in July. Thus the number of individuals of *Mirabilis jalapa* in $1m^2$ represents only the standing field population.

The standing population curve showed an exponential population growth from the month of January to April and thereafter it remained stationary until July. The population decline started from the month of August till December. The population of *Mirabilis jalapa* completed its one year life cycle in December. The germination started again in the month of January. Therefore, standing population of *Mirabilis jalapa* recorded in the month of January and in later months includes both the newly germinated ones and remanants of the last year (Figure 16B). The survivorship of the standing population of *Mirabilis jalapa* per m^2 showed a consistent decrease in its population from April to August. The surviving individuals of *M. jalapa* in the month of February and March were considerably high as the standing population included live individuals of previous year and newly germinated ones (January to mid February and unusually in July). Thus, overall number in standing population consistently increased until the month

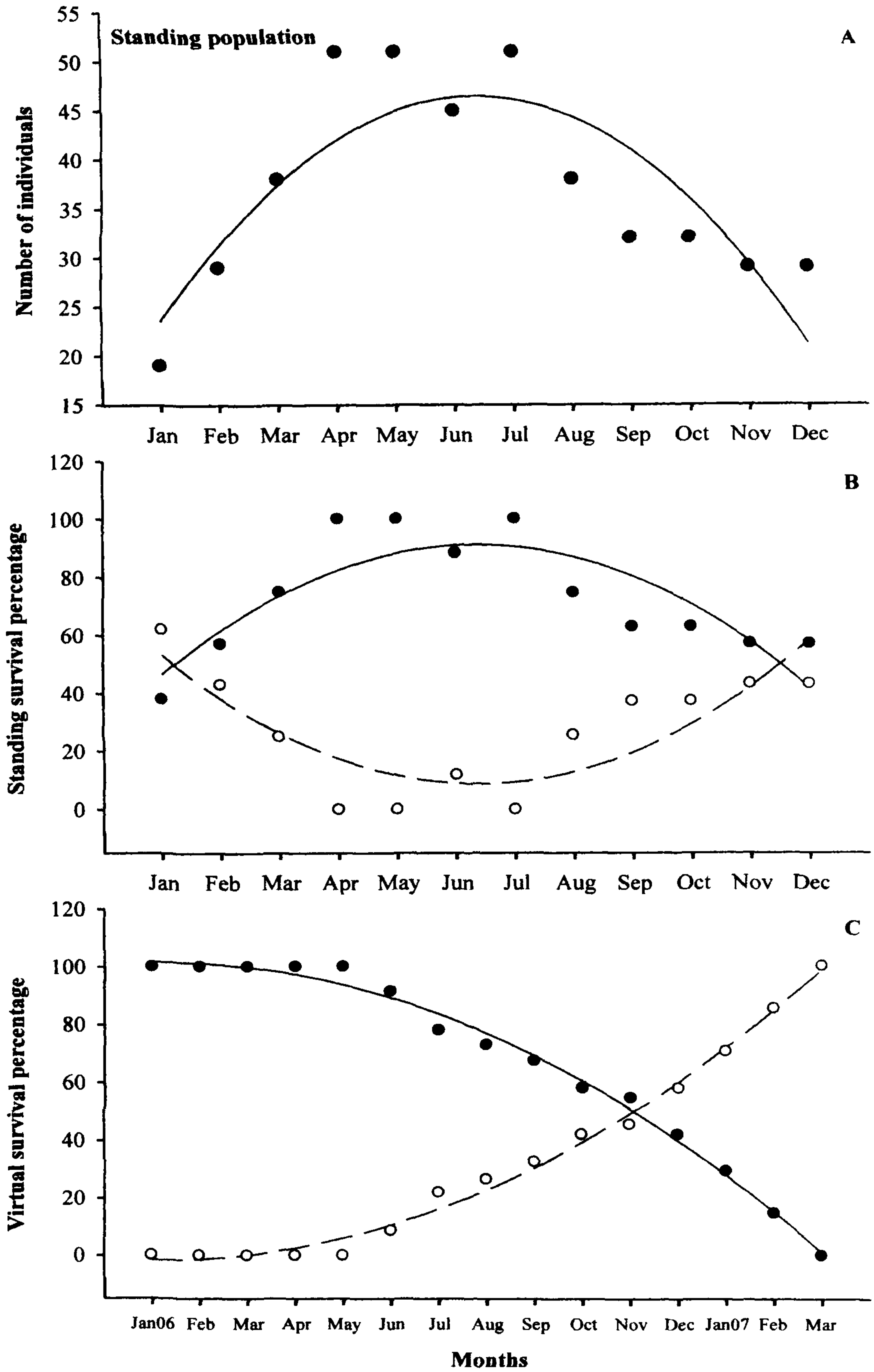


Figure 16. Survivorship (●) and mortality (O) curves of *Mirabilis jalapa* of standing population or virtual trends at invaded Site 1. Standing survivorship curve shows trends including surviving population of current and previous year and virtual survivorship curve shows trends of current year population.

of April and unusually in July. The standing mortality rate declined to zero between April-July due to replacement of dying ones by larger number of newly germinated individuals (Figure 16B).

In the month of January of the following year (2006), 50 individuals of *Mirabilis jalapa* of equal growth vigour were randomly selected and marked at site 1 and their number was recorded at monthly interval to workout the virtual survival and mortality of *M. jalapa* in the field. All marked individuals survived until May and then their number consistently declined from June (2006) to March (2007). The curve between virtual percent survival and age was neither exactly diagonal nor convex in the field. The population completely disappeared by the month of March 2007 (Figure 16C). The trend of mortality was reverse of the survivorship. The curve of survivorship and mortality crossed each other in the month of November showing 50% survival and 50% mortality (Figure 16C). The mortality rate increased from the month of December (2006) and attained 100% mortality by March 2007 (Figure 16C).

Growth, life cycle and survivorship curves of *Ruellia tuberosa*

a) Plant growth

The *Ruellia tuberosa* germinates in the month of April. The population of *Ruellia tuberosa* at invaded sites bloomed from July to November (Figure 20, 22 and 23). The vegetative blooming (plant growth in term of plant height) was high from August to March (following year). The leaf production and expansion during monsoon months (July to September) was high in cultivated individuals (Figure 17B). The growth performance of *Ruellia tuberosa* varied under field conditions. Contrary to *Mirabilis jalapa*, the plant height of *Ruellia tuberosa* decreased under field conditions at both the invaded Site 2 and 3 (Figure 17A). The total leaf area and leaf number per individuals of

Plate 4

A – Seedlings of *Ruellia tuberosa* 7 days after germination in pot in April.

B and C – Seedlings of *Ruellia tuberosa* germinated in April at Site 2 (B) and 3 (C).

D – *Ruellia tuberosa* in reproductive growth phase (budding, flowering, fruiting and seed setting) grown in pots with adequate moisture for the study of life cycle.

E and F –Post-flowering stage (→) of *Ruellia tuberosa* at Site 2 (E) and 3 (F).

Bars equal to 100mm.

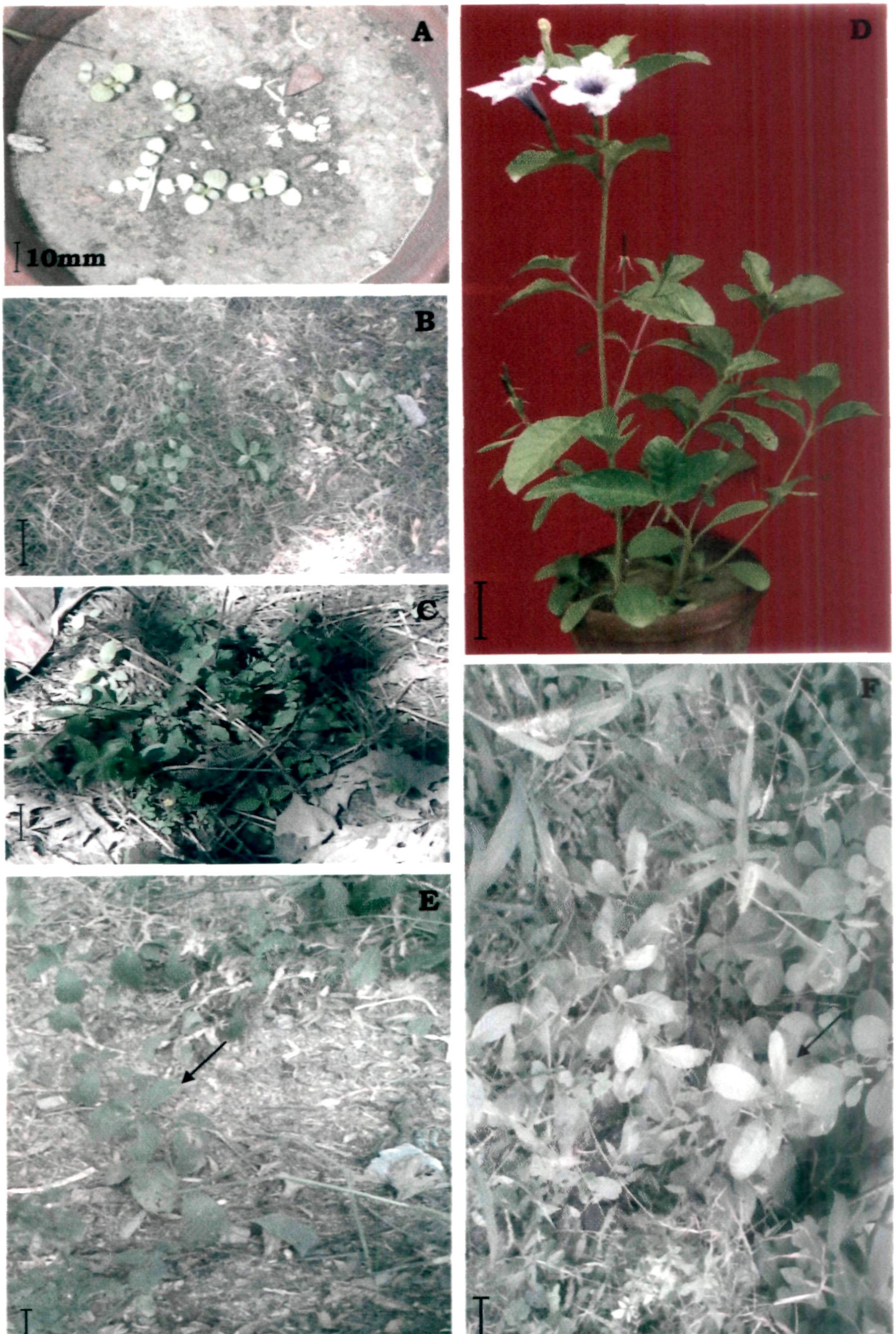


Plate 4

R. tuberosa varied at both the sites significantly. But, plant height did not differ significantly at both the sites (Figure 17A, B and C). The leaf number per plant of *Ruellia tuberosa* at Site 2 increased between July to September, declined from October until complete drying in the month of January. The leaf number was highest during July to October (Figure 17B). The total leaf number per plant of *Ruellia tuberosa* at Site 3 was lowest from December to February and dried completely by the month of April (Figure 17B). The overall leaf size (leaf area) of cultivated plant was larger and increased exponentially from May to September (Figure 17C). But, the leaf area of *R. tuberosa* at Site 2 and 3 increased from May to July and again from December and January of the following year. The increase in average leaf area per plant may be due to emergence of new leaves despite reduced leaf size. The overall total green leaf area was highest from July to September in cultivated plants and July to November at Site 2 and Site 3 (Figure 17C and D).

The relative water content (RWC) in *Ruellia tuberosa* did not show high degree of variations between pot cultivated, Site 2 and Site 3 plants (Figure 18A). The chlorophyll-b content in pot grown plants of *Ruellia tuberosa* was high between May to September and thereafter it declined consistently (Figure 18C). The overall chlorophyll content was relatively high in cultivated individuals as compared to invasive individuals at Site 2 and Site 3. The plants at Site 2 matured and dried by the month of February or March and thus the chlorophyll content was not estimated in these months. Chlorophyll-a in cultivated individuals consistently increased from May to September and declined until the month of December. At early growth stages (May to September), the chlorophyll-b content in potted individuals of *Ruellia tuberosa* differed considerably with those of invasive individuals at Site 2 and 3 (Figure 18C).

The stomata number on adaxial surface in pot cultivated plants of *Ruellia*

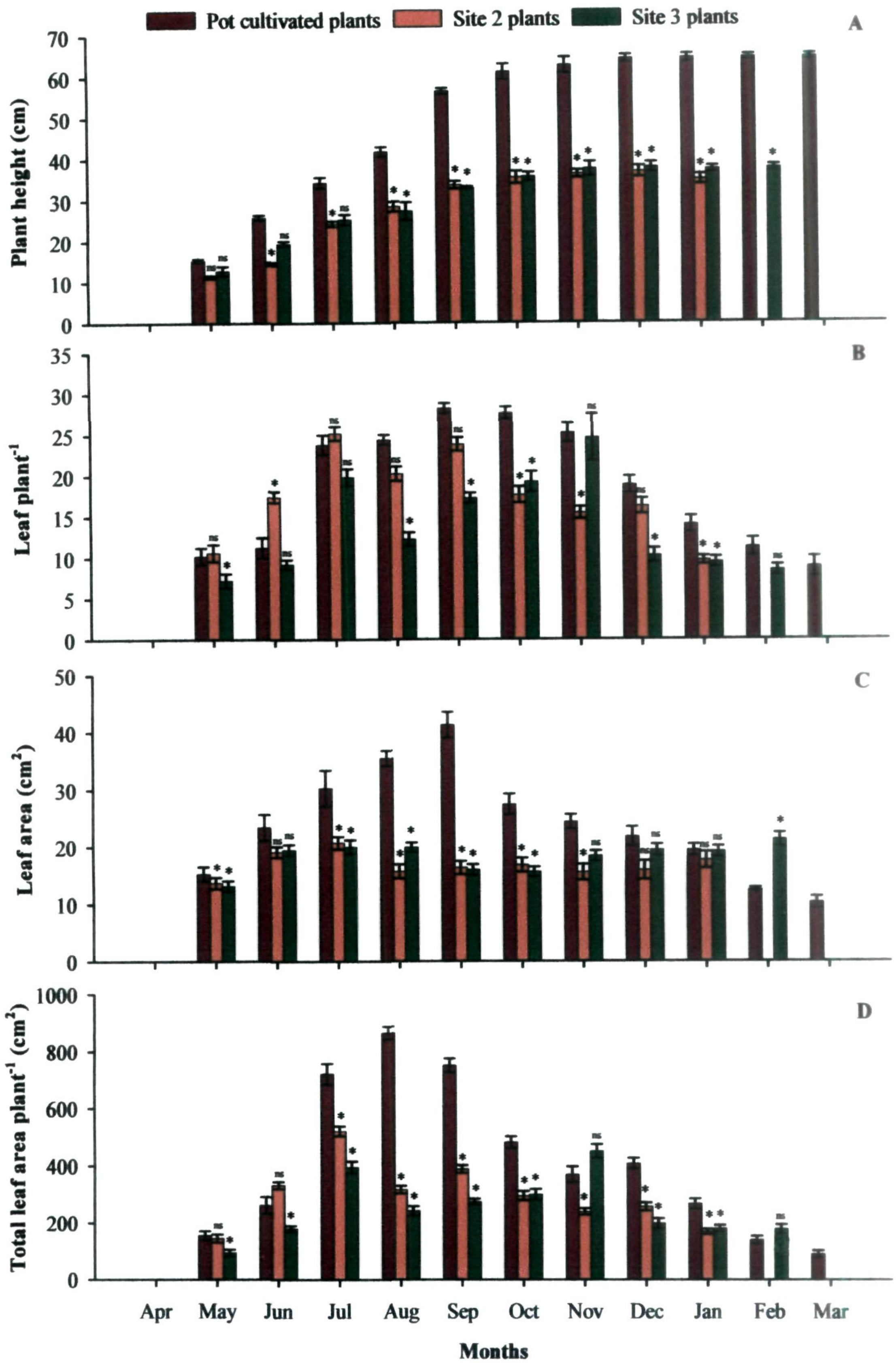


Figure 17. A comparative account of the growth (plant height, leaf plant^{-1}, Leaf area, total leaf area plant^{-1}) of *Ruellia tuberosa* grown in pots and at invaded Sites (2 and 3) (Data in annexed Table 26).
(Bars show mean±SE and significance of difference between sample means);
*significant at 5% level and ns as non-significant.

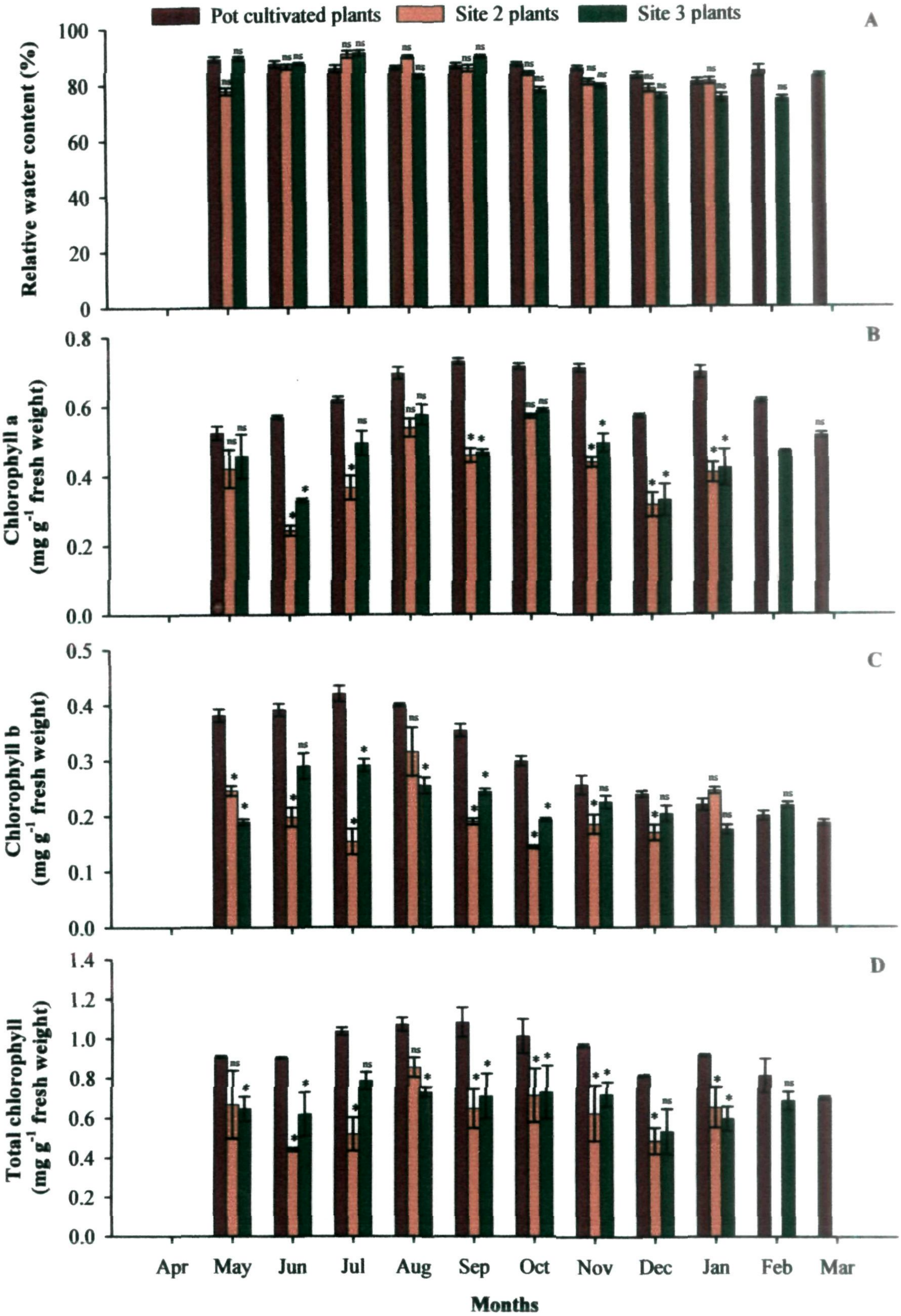


Figure 18. A comparative account of the biochemical leaf traits (relative water content and chlorophyll content) of *Ruellia tuberosa* grown in pots and at invaded Sites (2 and 3) (Data in annexed Table 27).
(Bars show mean±SE and significance of difference between sample means);
*significant at 5% level and ns as non-significant.

tuberosa was relatively high as compared to those growing in the field from May to September (early growth stage). From October to January, the stomata number on adaxial surface declined in both pot cultivated and Site 2 plants. The stomata number on abaxial surface in cultivated plants was significantly higher as compared to invasive individuals (Figure 20B). The stomatal index of Site 3 individuals was higher between August to October (Figure 20D).

The flowering in pots began in the month of June and attained its full bloom in September-October. The bud formation and flowering increased consistently from June to October in potted plant. The floral bud formation at Site 3 began in the month of June (Figure 20A), but the flowering started July only. At Site 2, the total period of floral bud formation and flowering was shorter as both the phases were recorded in the month of July (Figure 20A and B). The highest bud formation and flowering at Site 2 and Site 3 was recorded in August and October, respectively (Figure 20A and B). But overall flowering bloom of *Ruellia tuberosa* was highest in August at invaded sites and October in potted plants (Figure 20B). The fruit setting phase was longest in cultivated plants of *Ruellia tuberosa* and shortest at Site 3 (Figure 20C). The plants of *R. tuberosa* cultivated in pots (with adequate moisture) had highest seed per pod and longest seed setting period (July to February). At Site 2 and Site 3, the seed setting period extended from August to January. The variations in seed number per pod in cultivated and wild plants of *Ruellia tuberosa* (Site 2 and 3) were relatively lesser as compared to variations in number of floral buds, flowers and fruits (Figure 20A, B, C and D). The seed output was highest in the month of October and November in pot cultivated plants.

b) Biological clocks

The biological clocks of *Ruellia tuberosa* cultivated in pots and of those invaded

Plate 5

A, B and C – Leaf peal of adaxial surface of *Ruellia tuberosa* showing high number of stomata in September in pot (A), Site 2 (B) and Site 3 (C) individuals.

D, E and F – Leaf peal of adaxial surface of *Ruellia tuberosa* showing low number of stomata of in January in pot (D), Site 2 (E) and Site 3 (F) individuals.

G, H and I – Leaf peal of abaxial surface of *Ruellia tuberosa* showing highest number of stomata in pot (in October) (G), Site 2 (in June) (H) and Site 3 (in October) (I) individuals.

J, K and L – Leaf peal of abaxial surface of *Ruellia tuberosa* showing low number of stomata in pot (in January) (J), Site 2 (in January) (K) and Site 3 (in August) (L).

M, N and O – V.S. of leaf of *Ruellia tuberosa* showing variable proportions of leaf tissues (palisade, spongy parenchyma, vascular area) in pot (M), Site 2 (N) and Site 3 (O) individuals.

Bars equal to 50µ (A to L) and 100µ (M to O).

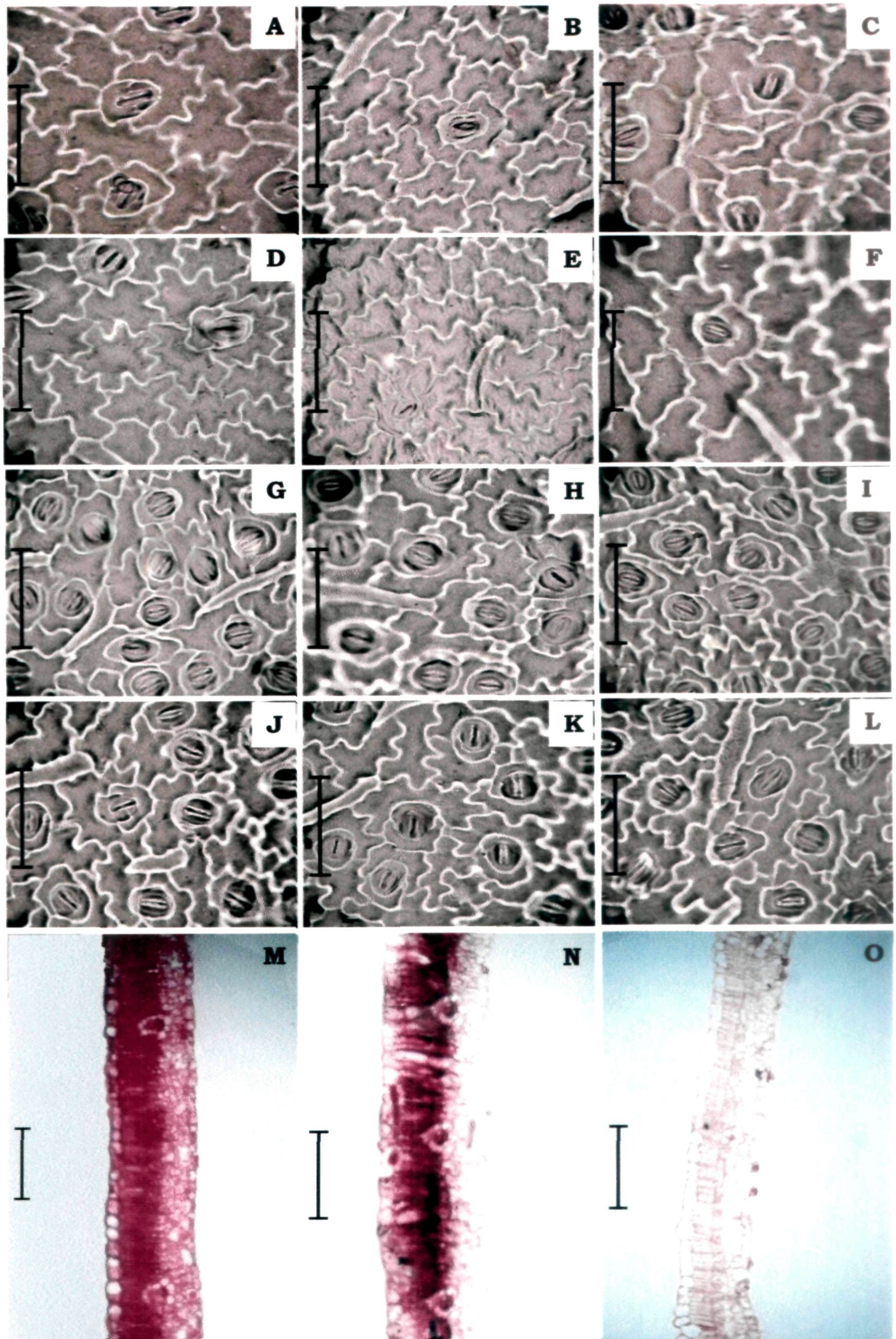


Plate 5

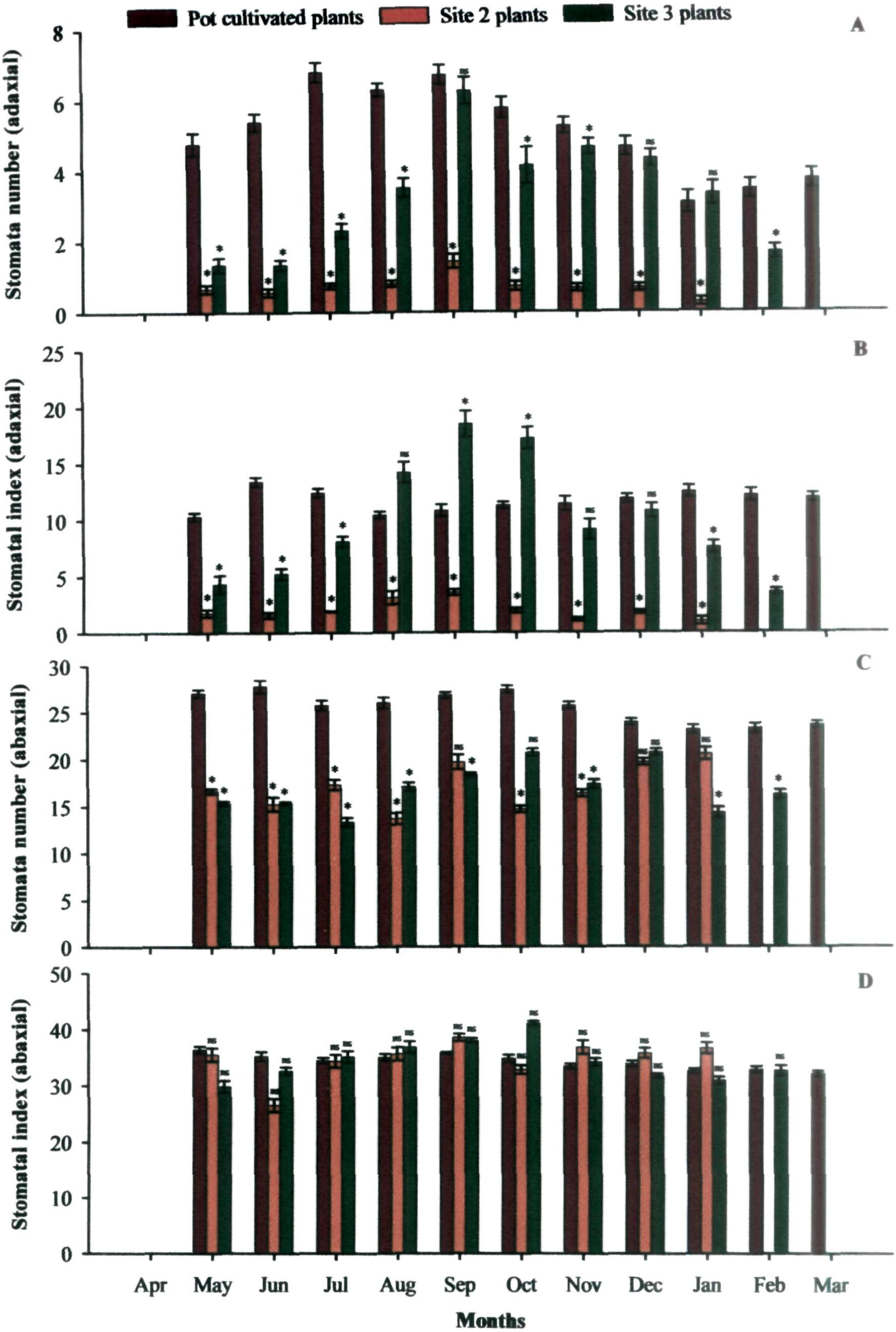


Figure 19. A comparative account of the micromorphological leaf traits (stomata number and indices) of *Ruellia tuberosa* grown in pots and at invaded Sites (2 and 3) (Data in annexed Table 27). (Bars show mean±SE and significance of difference between sample means); *significant at 5% level and ns as non-significant.

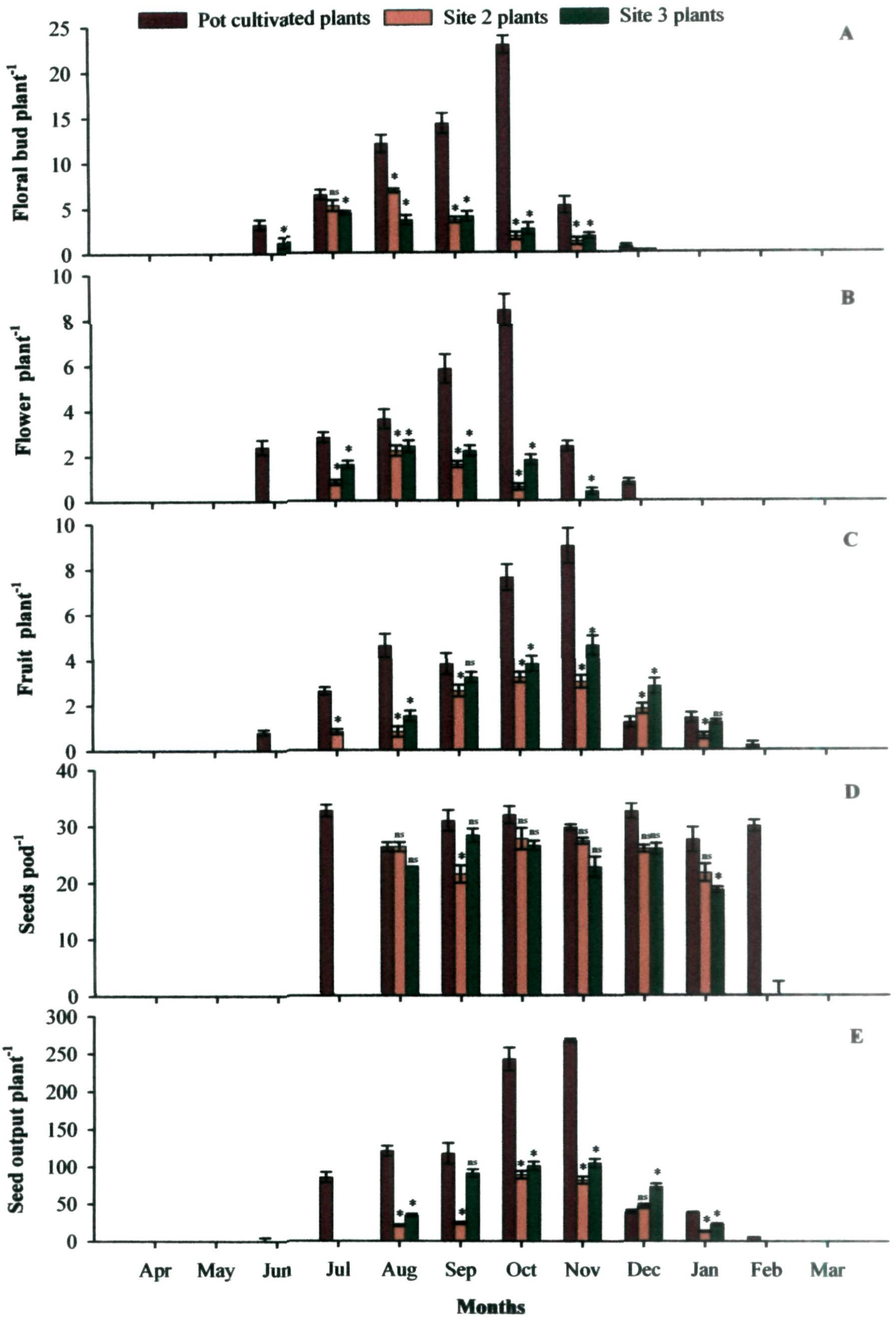


Figure 20. A comparative account of the reproductive growth (floral bud plant^{-1}, flower plant^{-1} fruit plant^{-1}, seeds pod^{-1} and seed output plant^{-1}) of *Ruellia tuberosa* grown in pots and at invaded Sites (2 and 3) (Data in annexed Table 26).
(Bars show mean±SE and significance of difference between sample means);
*significant at 5% level and ns as non-significant.

at Site 2 and Site 3 varied considerably in terms of total life span (Figure 21, 22 and 23). The total span of life cycle of *Ruellia tuberosa* was over 1 year when maintained in pots. But invasive individuals at Site 2 and Site 3 had 10 and 11 months life span, respectively. The pot cultivated plants after germination had 2 months (April and May) lag phase in growth. Similar, lag phase of 2 months was recorded in invasive individuals of Site 2 and Site 3 (Figure 22 and 23). But overall vegetative growth of cultivated individuals was faster and during exponential growth phase the vegetative and reproductive growth consistently increased for 6 months from June to November (Figure 21).. After exponential growth phase, the cultivated individuals had 4 months long decelerating vegetative and reproductive phase starting from December to March of the following year. The exponential growth phase was of 3 months (July to September) at Site 2 and of 4 months (June to September) at Site 3 (Figure 22). The total seed dormancy phase at Site 2 and 3 was of 3 months (January to March). The *Ruellia tuberosa* at Site 3 just remained alive with some vegetative parts (but no growth) in the month of February. The total period of reproductive growth (exponential and decelerating) was of 9 months in cultivated individuals, 7 months in invasive individuals at Site 2 and 8 months at Site 3 (Figure 21, 22 and 23). The comparison of life cycle shows that Site 3 was more invasible for *R. tuberosa*.

c) Survival curves

The survivorship and mortality curve of the standing population of *Ruellia tuberosa* invaded at Site 2 and 3 are shown in the figure 24B and 25B. The population of *Ruellia tuberosa* survived up to January and February at Site 2 and Site 3. The survival curve of standing population of *Ruellia tuberosa* at Site 2 and 3 were convex in pattern. The plant mortality rates increased at Site 2 from the month of December. Usually the germination starts in the month of April and continues up to month of May. The unusual

Figure 21

Biological clock of *Ruellia tuberosa* cultivated in pot

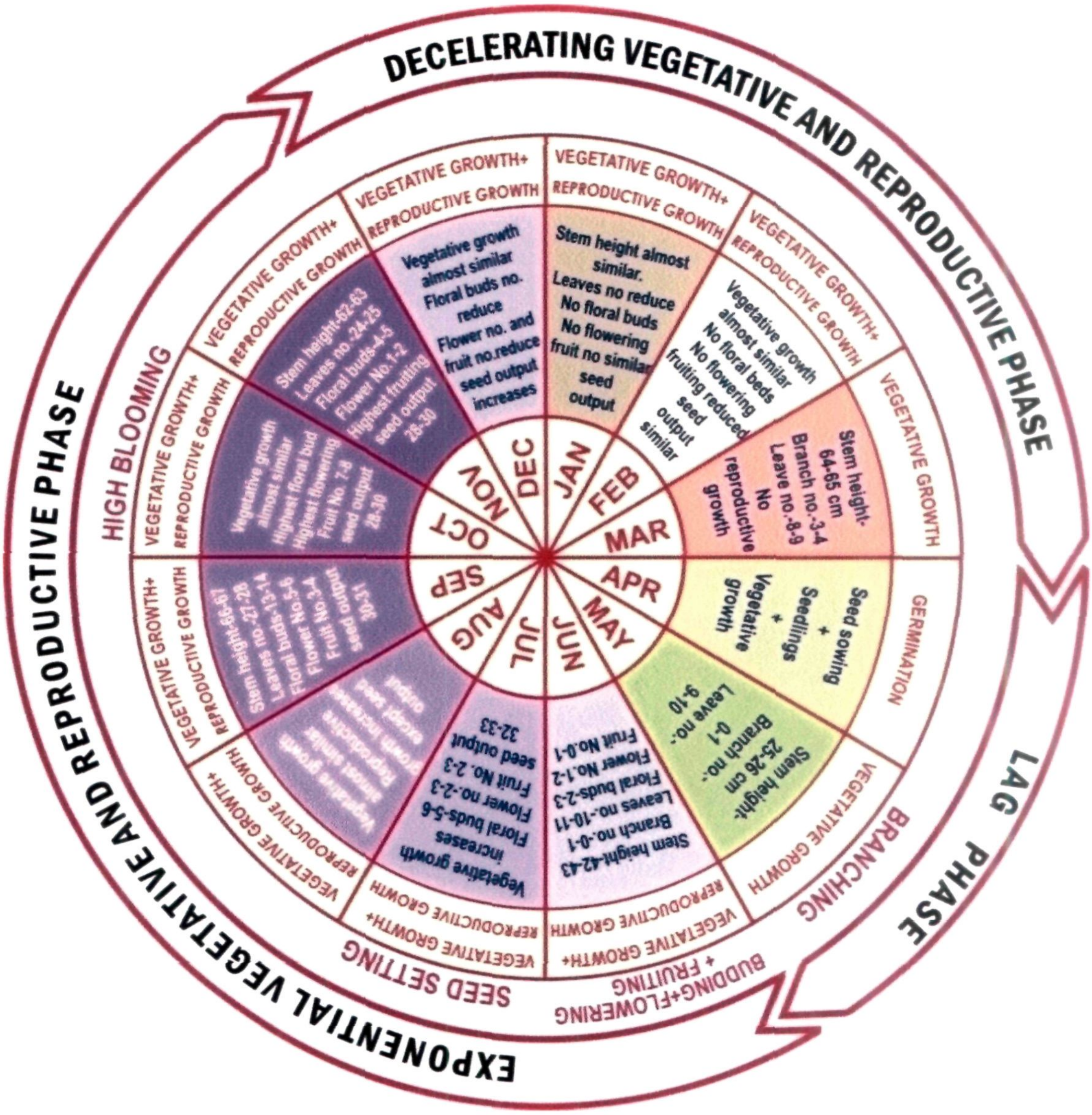


Figure 22

Biological clock of *Ruellia tuberosa* cultivated at Site 2

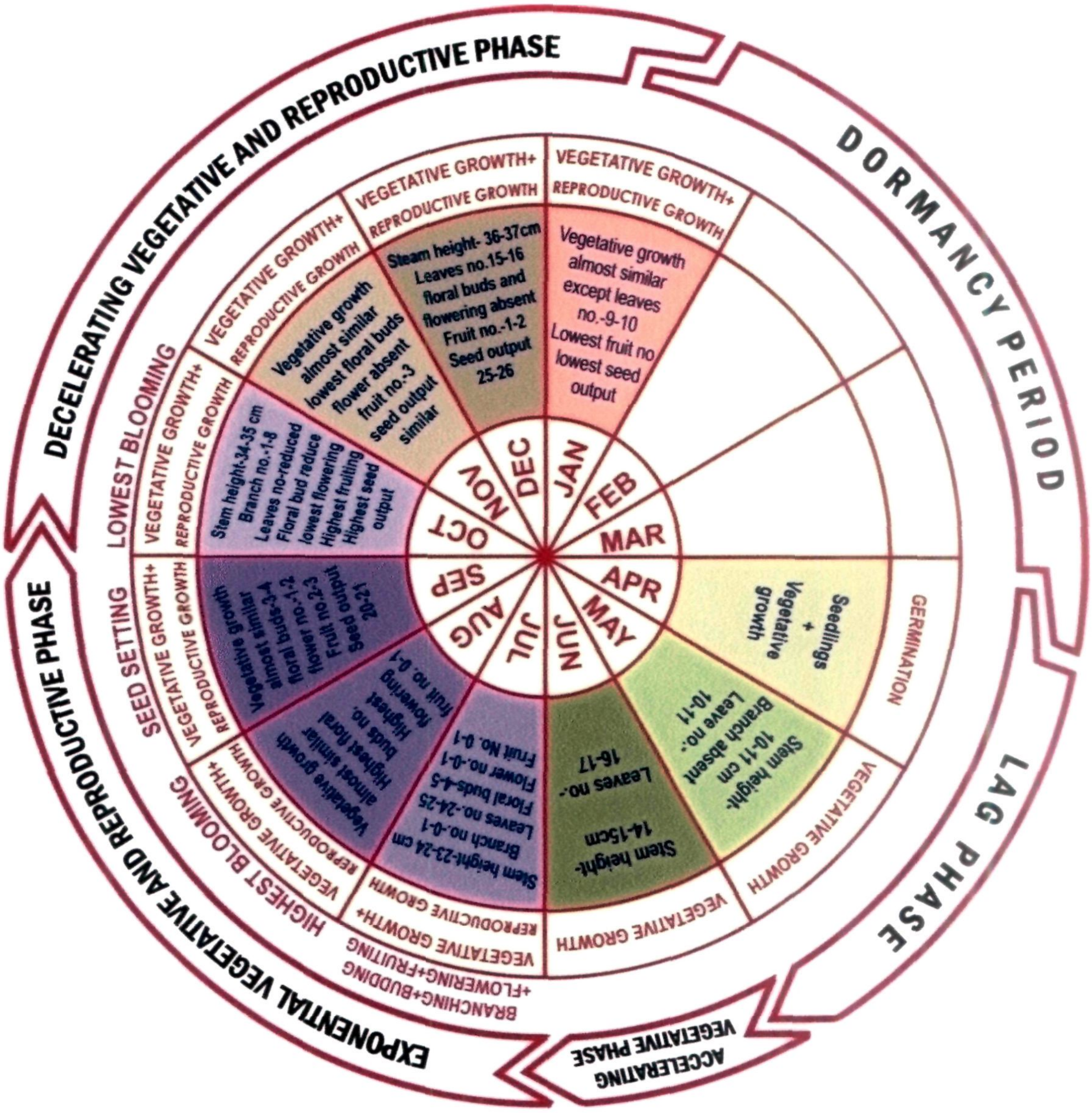
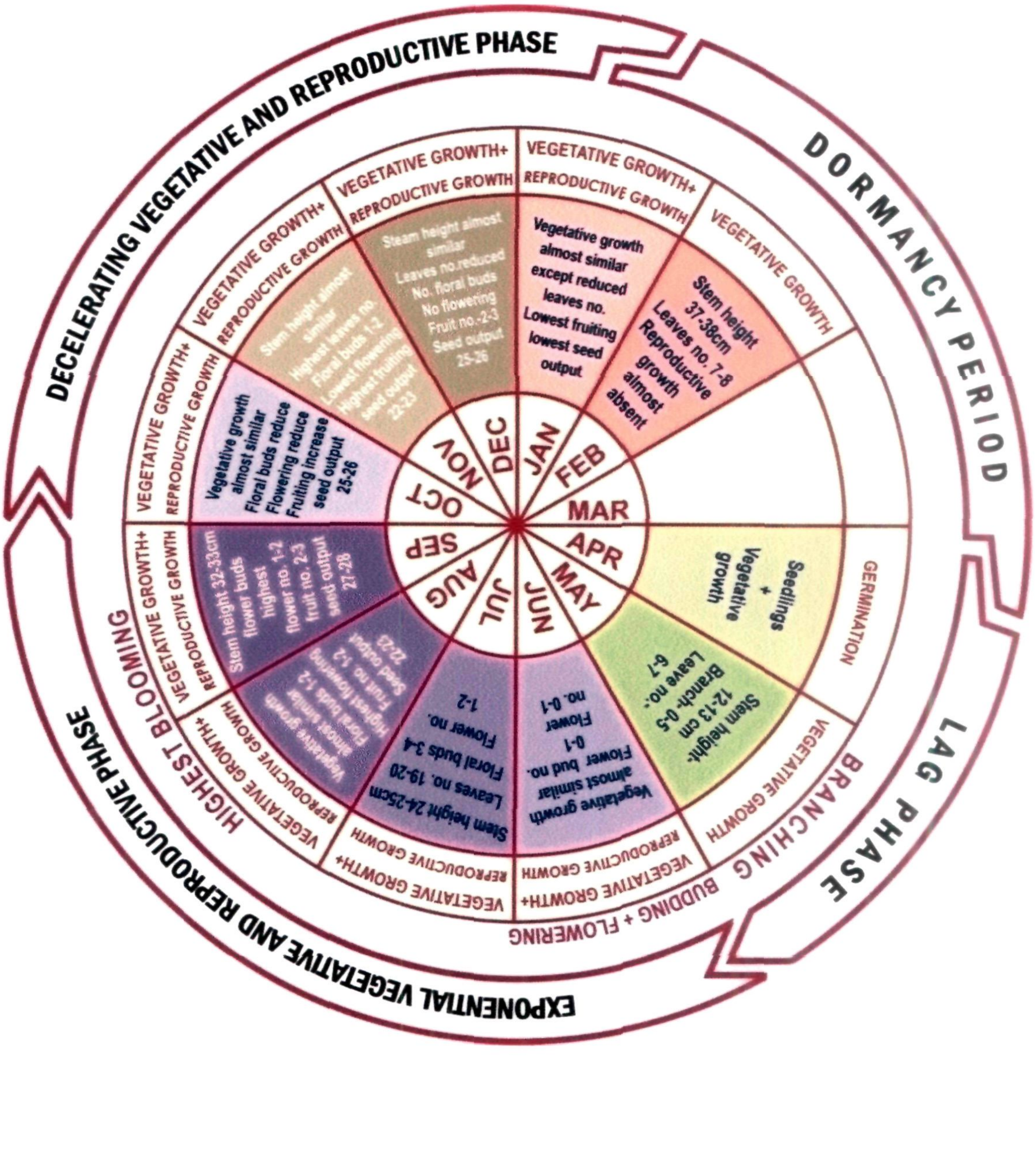


Figure 23

Biological clock of *Ruellia tuberosa* growing at Site 3



germination in the month of July and August increased the population count at Site 2 and thereby modified the pattern of standing population curve. At Site 3, the convex population curve was closer to actual number of standing individuals. The rate of mortality slowed down at Site 3. The virtual survivorship and mortality curves of *Ruellia tuberosa* (Figure 24C and 25C) is based on monthly counts of 50 marked individuals (germinated in the month of April) at both sites. The population of *R. tuberosa* had no mortality in the first three months of germination at Site 2 and in first two months at Site 3. The mortality curves were close to zero in first five months (April to August) at Site 2 and first 3 months (April to June) at Site 3 (Figure 24 and 25). The virtual and standing population survival curves (Figure 24B, 24C, 25B and 25C) of Site 2 and 3 are similar in pattern (convex). The seed dormancy of *R. tuberosa* was not perfectly maintained at both the invaded sites as evident from the unusual germination in the month of July and August (Figure 24 and 25).

Aggressive capacity

The reproductive capacity and average seed output of *Mirabilis jalapa* at Site 1 and those cultivated in pots (Figure 26A) were statistically similar (non-significant difference). Thus the aggressive capacity and seed output remained same either the individuals were cultivated or escaped into the field. But the reproductive capacity and average seed output of *Ruellia tuberosa* reduced significantly at invaded Sites 2 and 3 as compared to pot cultivated individuals (Figure 26A). The plants of *Mirabilis jalapa* had excessive above ground biomass at Site 1 as compared to pots (Figure 26B). In *Ruellia tuberosa*, the relative proportion of above ground biomass and seed production was highly variable in the individuals of pots and invasive Sites 2 and 3 (Figure 26B).

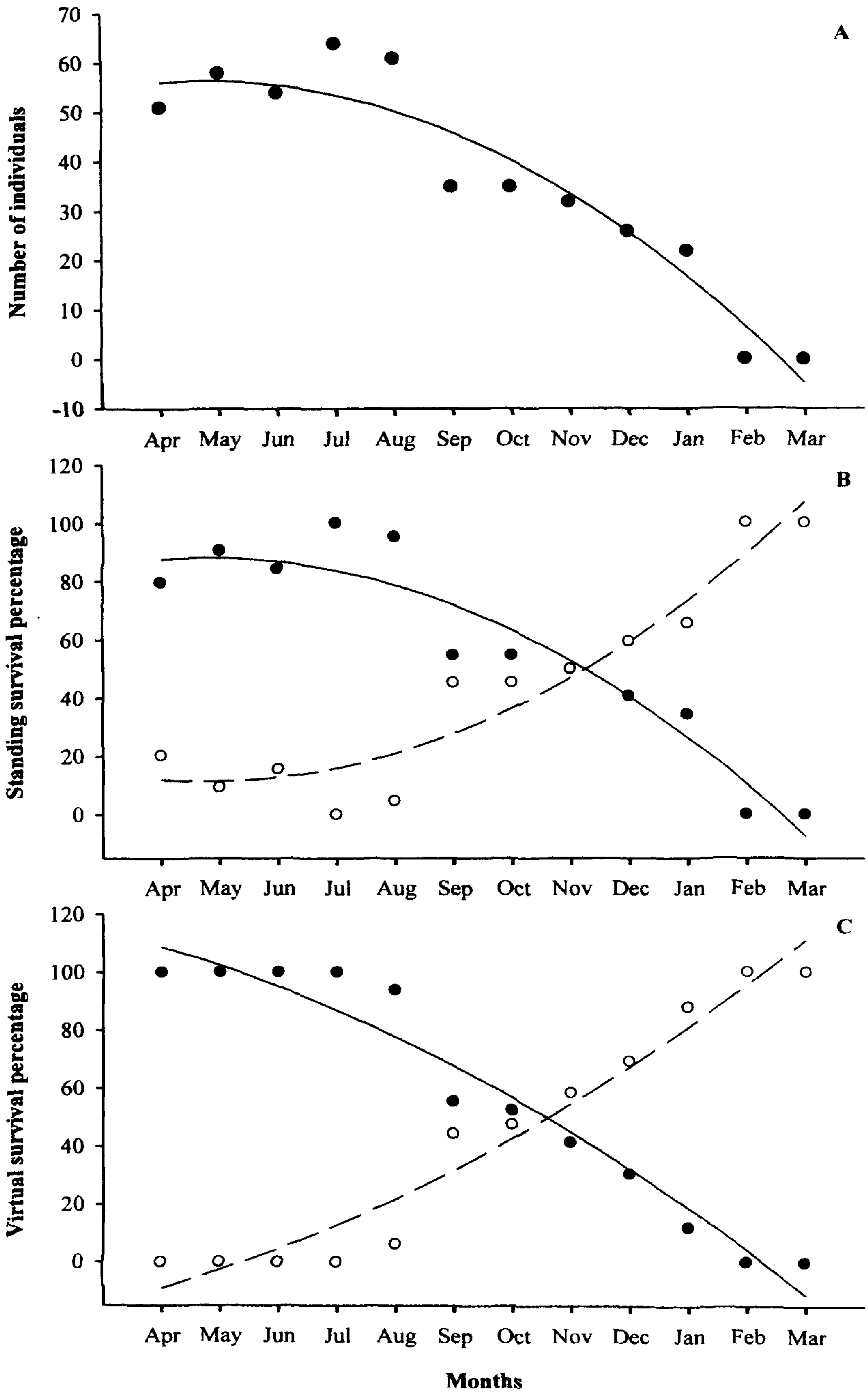


Figure 24. Survivorship (●) and mortility (○) curves of *Ruellia tuberosa* of standing population or virtual trends at invaded Site 2. Standing survivorship curve shows trends including surviving population of current and previous year and virtual survivorship curve shows trends of current year population.

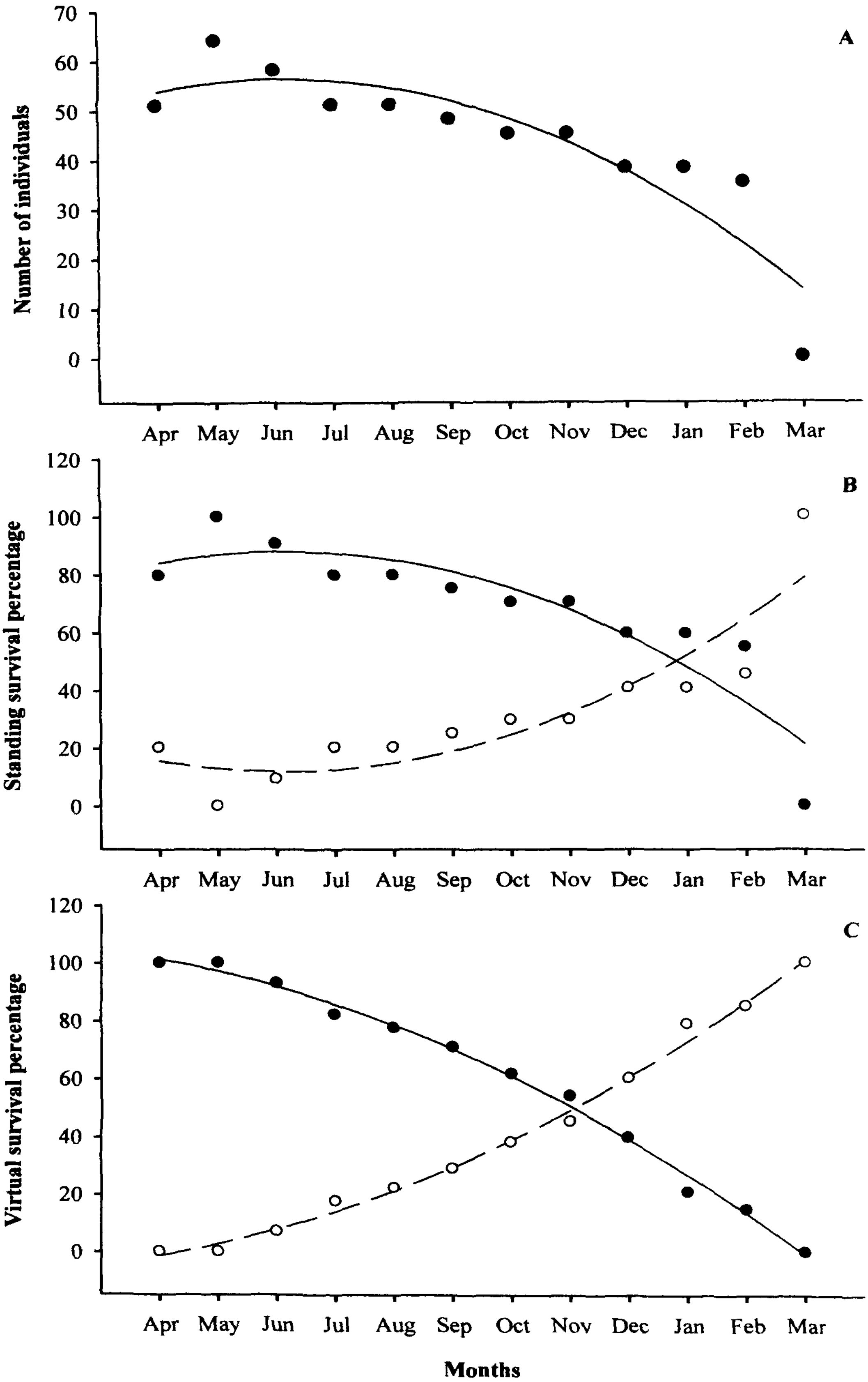
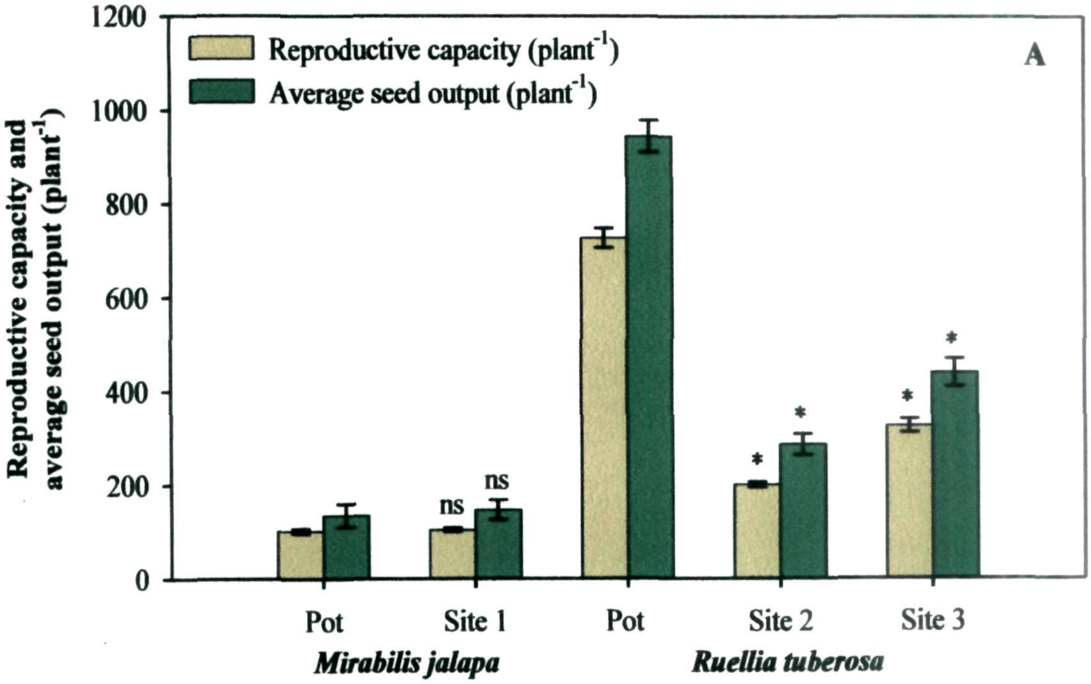


Figure 25. Survivorship (●) and mortility (○) curves of *Ruellia tuberosa* of standing population or virtual trends at invaded Site 3. Standing survivorship curve shows trends including surviving population of current and previous year and virtual survivorship curve shows trends of current year population.



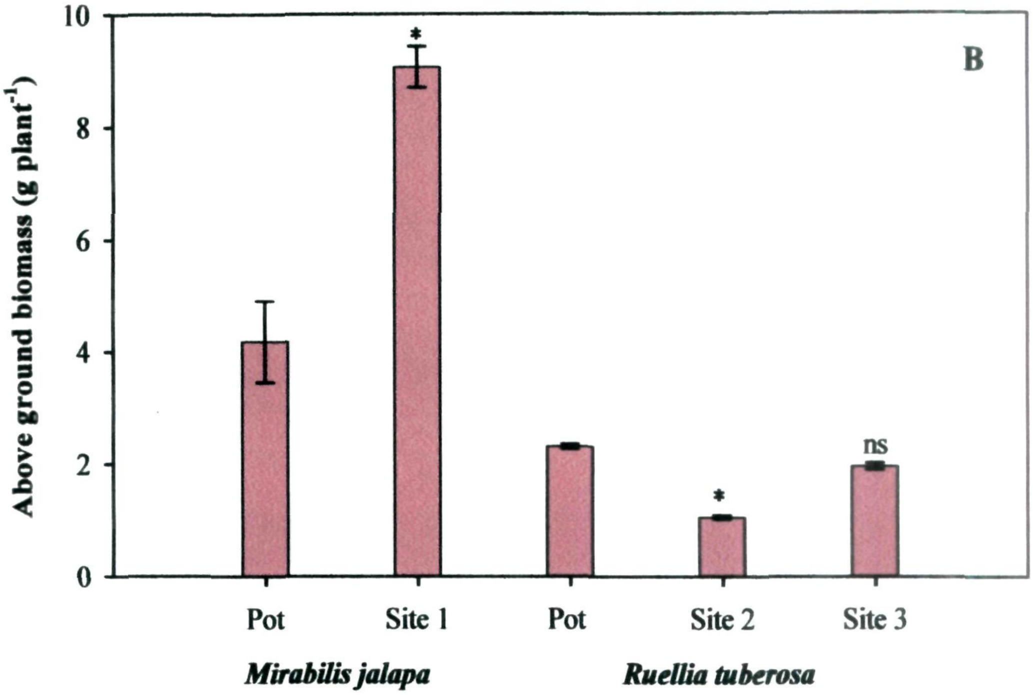


Figure 26. A. Average seed output plant^{-1} and reproductive capacity, **B.** Above ground biomass of both the selected species at their respective sites and cultivated in pot (with adequate moisture and light).

Histological variation in selected plants

Pie diagrams in Figure 27 show the relative proportion of four major tissues systems in mature leaf at 2^{nd} or 3^{rd} internode of both the selected species either grown in pots or collected from their respective sites. The tissue systems include proportions (per cent area) of dermal system (total area of adaxial and abaxial epidermis), palisade layer, spongy layer and vascular system (vascular bundles). At invaded Site 1, the area of spongy parenchyma in *Mirabilis jalapa* increased at the costs of dermal system and palisade layer. The proportion of vascular system also increased partially in *Mirabilis jalapa* at invaded Site 1 (Figure 27B).

In *Ruellia tuberosa*, the vascular area and dermal system slightly increased at invaded Site 2 and Site 3 (Figure 27D and E). The proportionate increase of dermal and vascular system was higher at Site 3. The spongy parenchyma in *Ruellia tuberosa* decreased at invaded sites as compared to pots while palisade area increased at invaded sites (2 and 3) as compared to plants cultivated in pots (Figure 27C, D and E).

Effect of varying water regimes

To study the effect of varying water regimes on the growth and adaptation of selected species, 5 sets of pot of each species were subjected to 5 levels of watering at 2 growth stages (pre-flowering i.e. 30 days after germination and post-flowering i.e. 60 days after germination). The 5 sets of each species at each growth stages were subjected for 5 weeks to five levels of watering as W_1 to W_5 (daily watering to 10 days interval) as per details in materials and methods (Page 39-40). Some non-destructive growth parameters (vegetative and reproductive) and cellular adaptations (stomata, area of tissue systems in leaf) were recorded at weekly intervals. The detailed analyzed data is presented in tables (Annexed as Tables 29-44). The pooled data of both the plants of

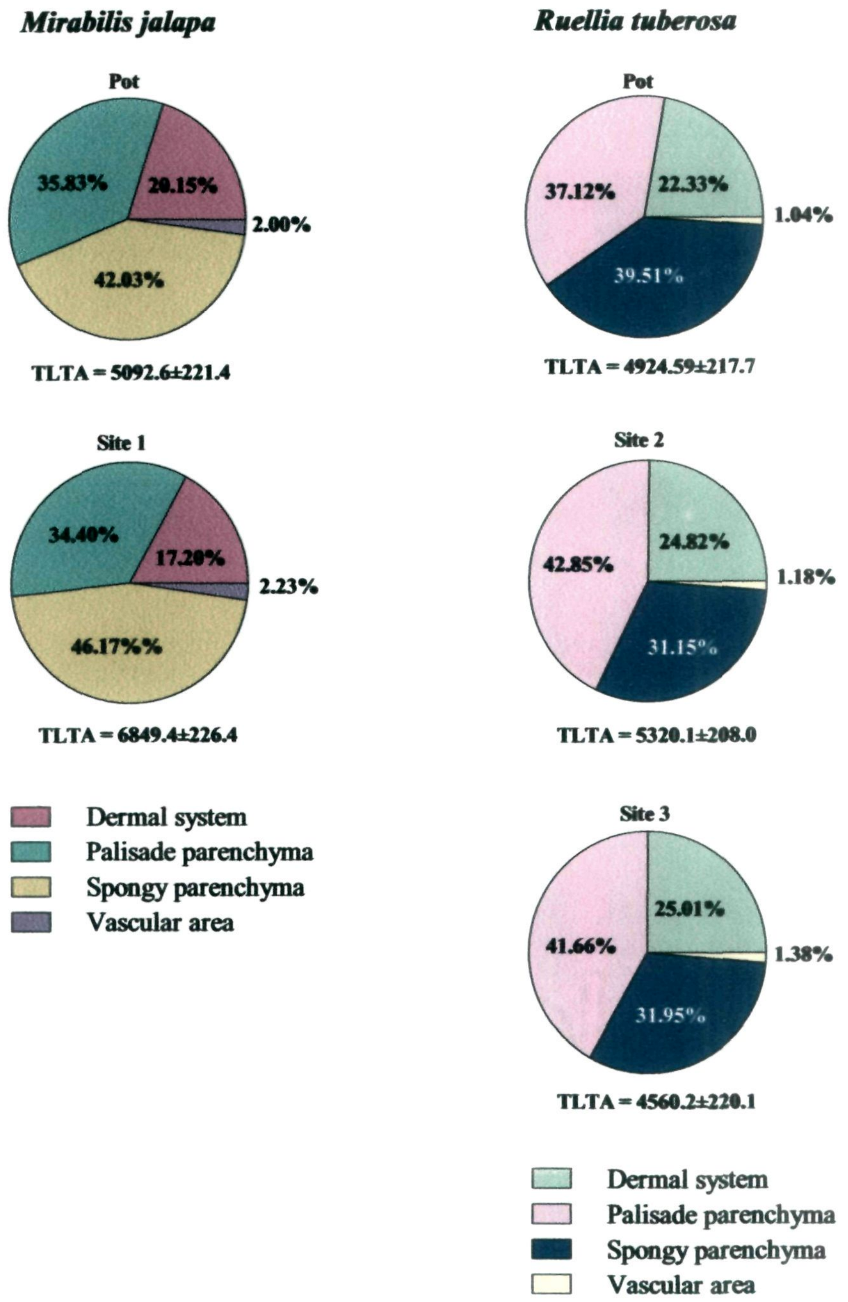


Figure 27. Relative proportion of leaf tissue systems of selected invasive species at their respective sites and cultivated in pots (with adequate moisture and light) (Data in annexed Table 28). Mean±SD, TLTA-Total leaf tissue area.

growth stage was used to determine the correlation coefficients and linear regression (LR) equation and lines between (i) Selected growth parameters vs watering levels (W_1-W_5) and (ii) Growth parameters vs weeks of stress. The responses and adaptations of both the selected plants to water stress are described below as a). Vegetative growth, b). Physio-biochemical variations, c). Histological variations and d). Reproductive growth:

a) Vegetative growth

The plant height at both the growth stages of *Mirabilis jalapa* was directly related with the number of watering days (Figure 28A-D). Maximum plant height was recorded in response to daily watering for 5 weeks at pre-flowering (30 days) and post-flowering (60 days) stages. The low soil moisture (3 times in 5 weeks i.e. watering at 10 days intervals) reduced stem height of *Mirabilis jalapa*. The linear regression (LR) line between plant height and water regimes was more strongly related with water treatments at pre-flowering stage as compared to post-flowering stage as evident from factor b of LR equation and per cent dependence of plant height over moisture levels (Figure 28B and C). The stem height of *Ruellia tuberosa* and water regimes were strongly correlated (Figure 28D). In contrary to *Mirabilis jalapa*, the per cent dependence of the stem height of *Ruellia tuberosa* over water regimes was stronger at post-flowering stage. The steepness (factor b of LR) in the regression line and equation between 2 factors was higher at 60 days growth stage of *Ruellia tuberosa* (Figure 28F).

The plant height (of both the species) and stress days water/watering days had stronger correlation at W_1, W_2 and W_3 watering levels (Figure 28B, C, E and F). The stem height of *Mirabilis jalapa* at post-flowering stage was more strongly related with the stress days at W_3 watering level as compared to response at pre-flowering stage (Figure 28Band C). At high water stress level (W_4), stem height suffered instant loss

Plate 6

A – Visual effect of varying water regimes (W_1, W_2, W_3, W_4 and W_5) on the growth of 60 days old *Mirabilis jalapa.*

B – Visual effect of varying water regimes (W_1, W_2, W_3, W_4 and W_5) on the growth of 60 days old *Ruellia tuberosa.*

Bars equal to 100mm.

Plate 6

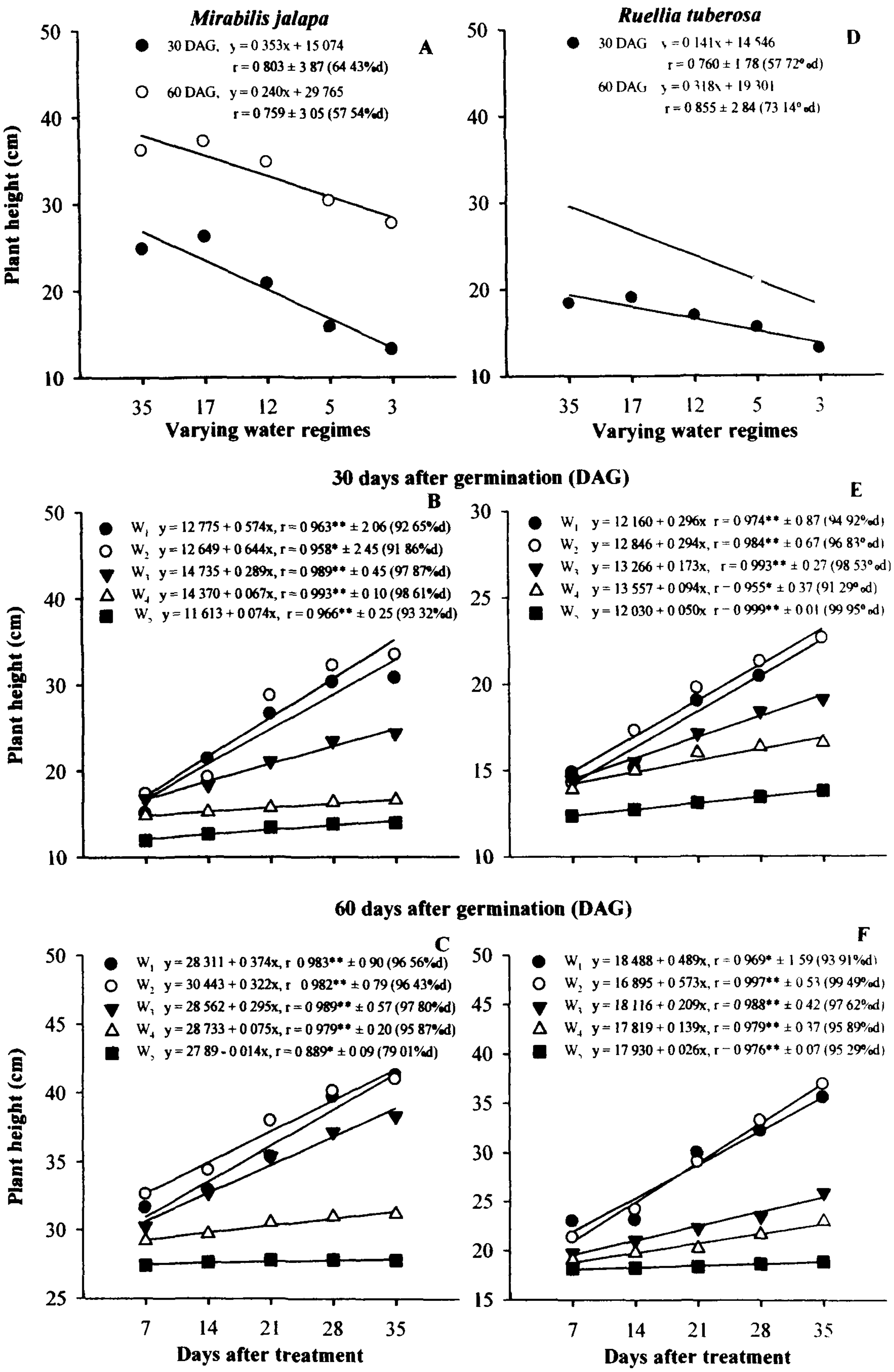


Figure 28. Regression line with the equation of y, correlation coefficient (r), ±SE(r), * significance and percent dependence (within parenthesis) of the height of selected species with respective varying water stress days (W_1-W_5). (Data in annexed Table 29)

during 1st week (at early and late growth stage) and therefore, the level of steepness in the regression line between plant height and stress days at W_4 stress level was not very sharp in *Mirabilis jalapa* (Fig 29B and C). In *Ruellia tuberosa* the plant height at pre- and post-flowering stages was more strongly related with the stress span (7 to 35 days) when irrigated daily (W_1) or at alternate days (W_2). The steepness (factor b of LR) between plant height of *Ruellia tuberosa* and water stress span (7 to 35 days) at low moisture level W_5 was relatively more prominent at pre-flowering (Figure 28E) than at post-flowering stage (Figure 28F). The comparative account of correlation coefficient and steepness in the regression line indicates that the *Mirabilis jalapa* at early stage is relatively more sensitive to water stress as compared to *Ruellia tuberosa* (Figure 28B and E).

The trend of regression line and correlation coefficient between leaves per plant of *Mirabilis jalapa* at varying water regimes was similar to that of plant height. But the degree of dependence of plant height on varying water regimes was stronger than the dependence of leaf number (Figure 29A). The leaf number in *Ruellia tuberosa* at pre-flowering stage was strongly correlated with varying moisture levels (Figure 29D). The correlation of leaf number with the number of stress days had both positive and strongly negative relation. The correlation coefficient and degree of dependence of leaf number over days of irrigation were negative and stronger at pre- and post-flowering stages of both the plants at W_1 and W_2 watering levels (Figure 29B, C, E and F). The negative correlation of leaf number with stress days (at W_4 and W_5 levels) indicates that leaf number decreased with increase in stress days in both the selected plants (Figure 29B, C, E and F). The non-significant correlation coefficient of leaf number of *Ruellia tuberosa* at W_3 levels indicates the optimum watering level (Figure 29E and F).

The area expansions per leaf in both the selected plants were more strongly

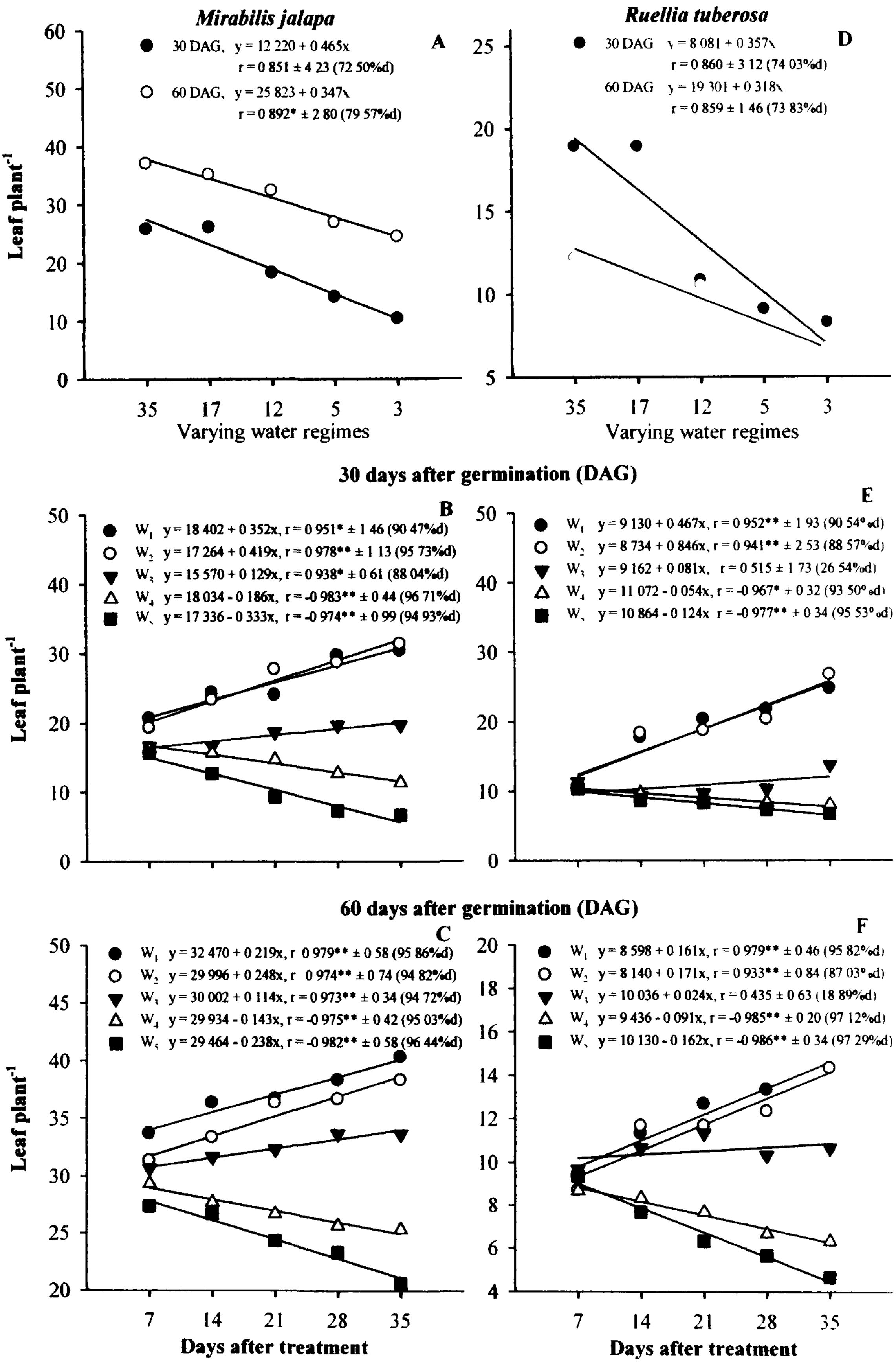


Figure 29. Regression line with the equation of y, correlation coefficient (r), ±SE(r), * significance and percent dependence (within parenthesis) of leaf $plant^{-1}$ of selected species with respect to varying water stress days (W_1-W_5). (Data in annexed Table 30).

correlated with total number of irrigation during 35 days of water treatment (Figure 30A and D). The degree of dependence of leaf area over irrigation days was stronger in *Ruellia tuberosa* than in *Mirabilis jalapa* but degree of steepness in the regression line (factor b in linear regression equation) between the 2 variables was more prominent in *Mirabilis jalapa* than in *Ruellia tuberosa*. The correlation coefficient between leaf area with respect to number of irrigation days were stronger on daily (W_1) or alternate days watering (W_2) in both the selected plants at pre- and post-flowering stages (Figure 30B, C, E and F). The degree of steepness (factor b) of the regression equation consistently decreased with decrease in moisture content (W_1 to W_5) in both the plants at both the growth stages. The result indicates that leaf expansion in both the plants depended not only on moisture level but also on the days of water.

b) Physio-biochemical variations

The relative water content (RWC) in the leaf tissues was positively correlated with stress days in both the plants facing stress either at pre- and post-flowering stage (Figure 31A and D). The degree of correlation and degree of steepness (factor b in linear regression equation) between RWC and number of stress days had similar patterns in both the species at pre- and post-flowering stages. The RWC in *Mirabilis jalapa* and *Ruellia tuberosa* at higher watering levels (W_1 and W_2) had lesser degree of steepness indicating that daily or alternate day watering suffice maintenance of RWC in both the species. The reduced moisture level (W_3, W_4 and W_5 levels) led to stronger correlation with stress days and maintained proportionately lesser RWC in the tissues (Figure 31).

The patterns of correlation coefficients and linear regression of leaf number (Figure 29) and chlorophyll contents (Figure 32, 33 and 34) with stress days are almost similar in both the species. The degree of dependence of chlorophyll-b on number of

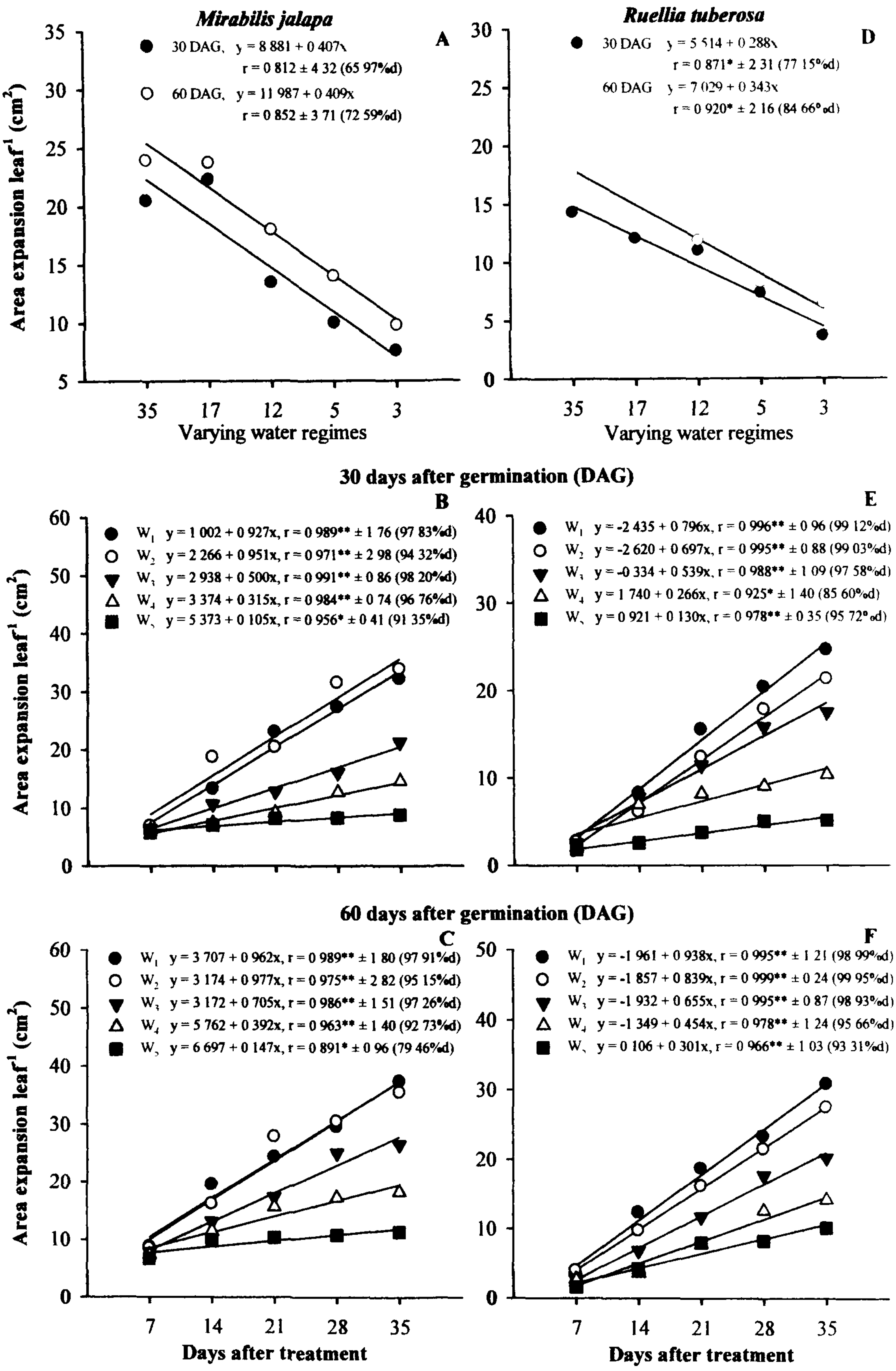


Figure 30. Regression line with the equation of y, correlation coefficient (*r*), ±SE(*r*), * significance and percent dependence (within parenthesis) of area expansion leaf[1] of selected species with to varying water stress days (W_1-W_5). (Data in annexed Table 31).

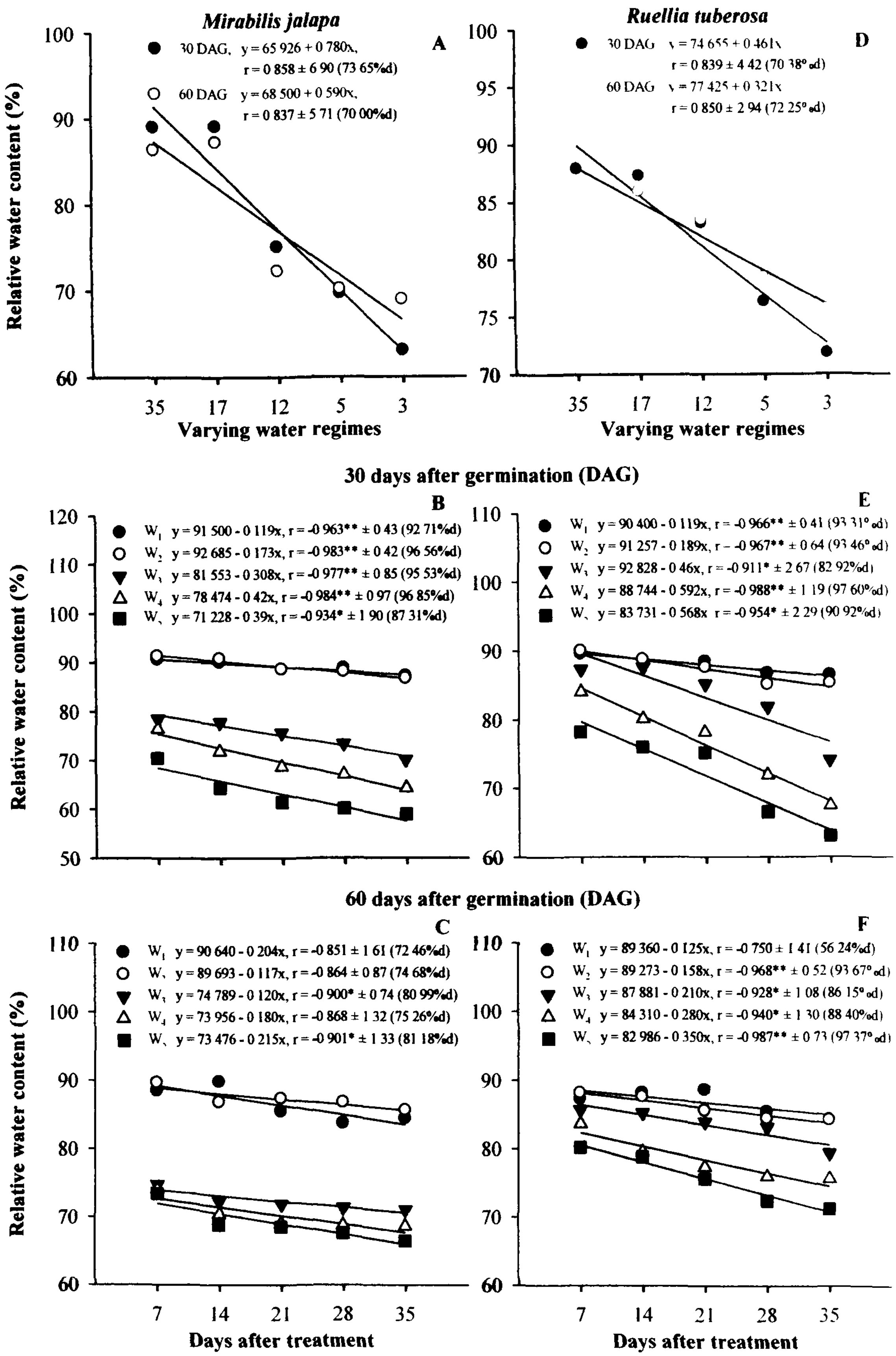


Figure 31. Regression line with the equation of y, correlation coefficient (r), ±SE(r), * significance and percent dependence (within parenthesis) of relative water content of selected species with respect to varying water stress days (W_1-W_5). (Data in annexed Table 32).

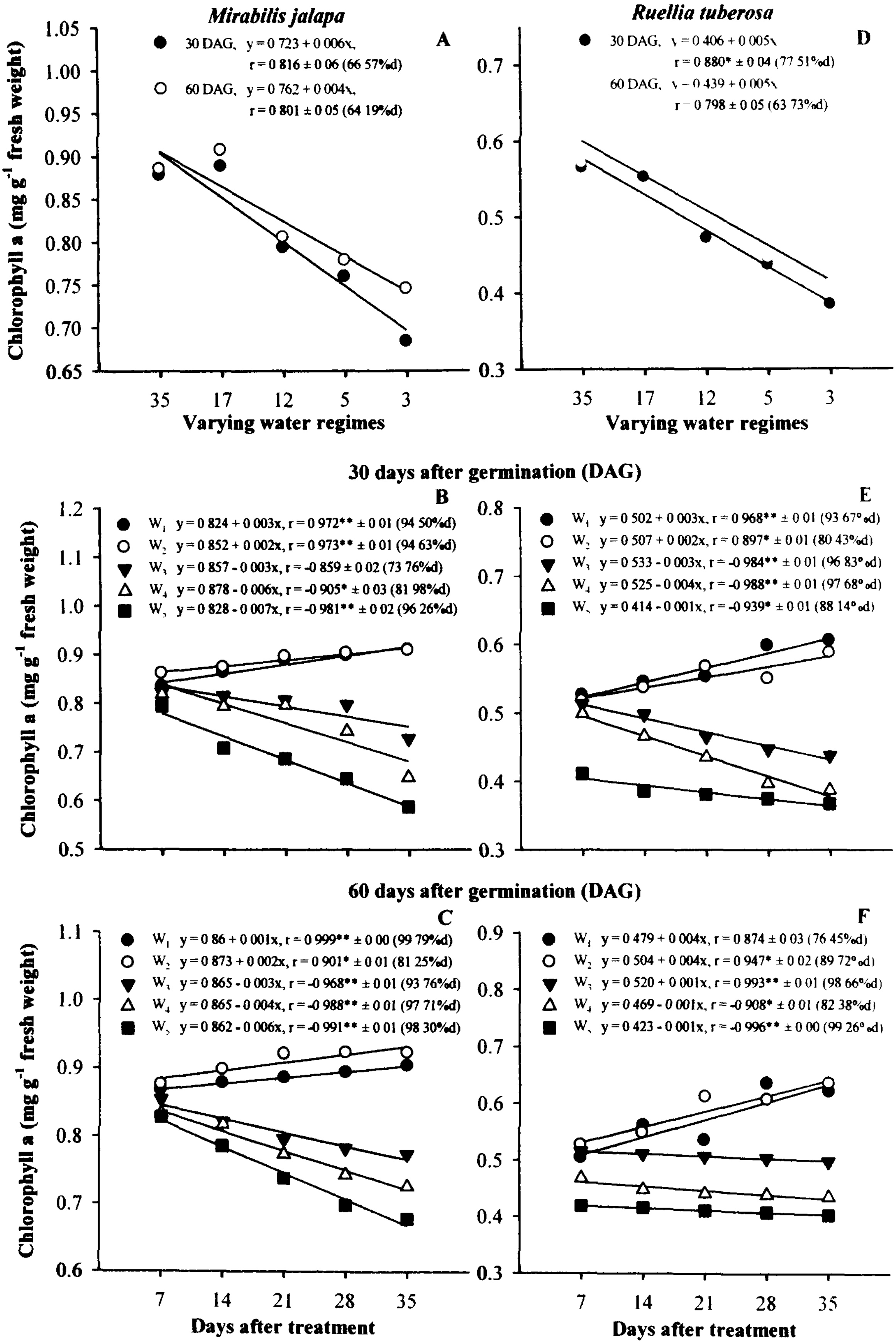


Figure 32. Regression line with the equation of y, correlation coefficient (r), ±SE(r), * significance and percent dependence (within parenthesis) of chlorophyll a of selected species with respect to varying water stress days (W_1-W_5). (Data in annexed Table 33).

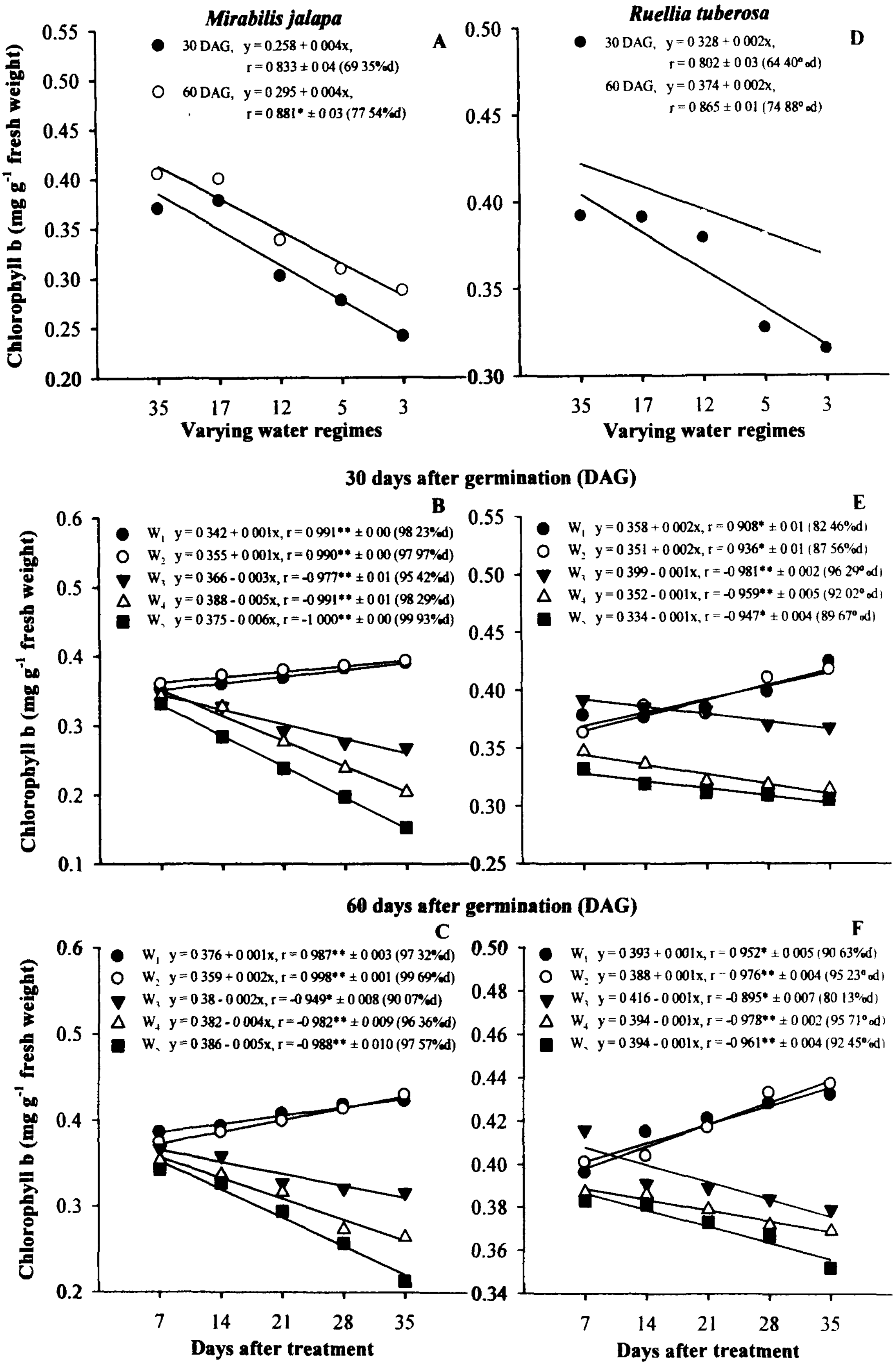


Figure 33. Regression line with the equation of y, correlation coefficient (r), ±SE(r), * significance and percent dependence (within parenthesis) of chlorophyll b of selected species with respect to varying water stress days (W_1-W_5). (Data in annexed Table 34).

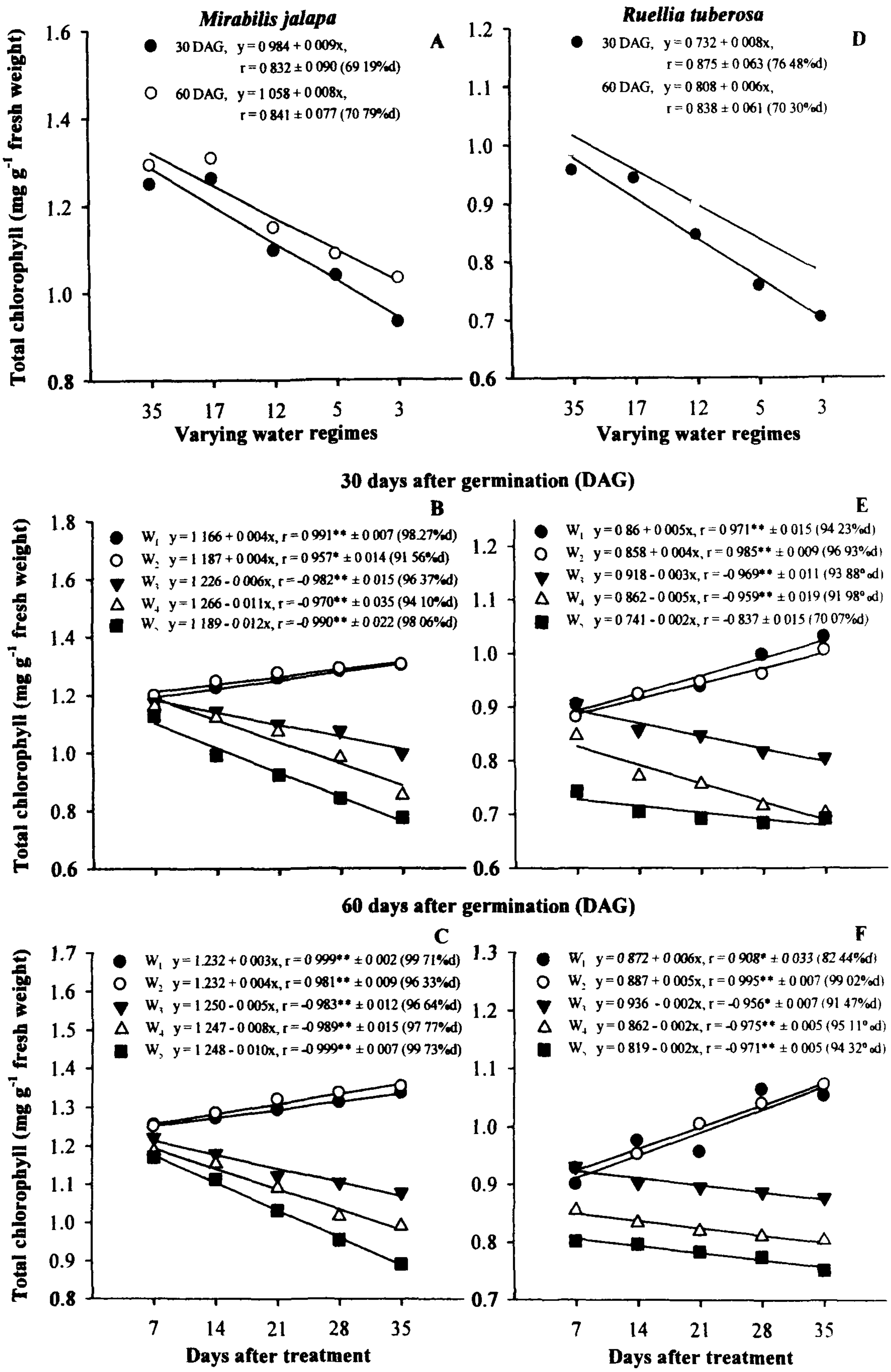


Figure 34. Regression line with the equation of y, correlation coefficient (r), ±SE(r), * significance and percent dependence (within parenthesis) of total chlorophyll of selected species with respect to varying water stress days (W_1-W_5). (Data in annexed Table 35).

water stress days was relatively higher than the dependence of chlorophyll-a (Figure 32 and 33). This indicates that longevity of water stress had affected chlorophyll content proportionately in addition to leaf emergence.

The moisture level (W_1–W_5) had a direct impact on the above ground biomass of both the species particularly at pre-flowering stage (Figure 35A and B). In both the species, above ground biomass directly depended on moisture stress (Figure 35). The above ground biomass of *Mirabilis jalapa* was relatively more strongly dependent on moisture stress than *Ruellia tuberosa* (Figure 35).

c) Histological variations

Stomata usually did not occur on adaxial surface of leaf in *Mirabilis jalapa*. In *Ruellia tuberosa*, the stomata were present on both surfaces (adaxial and abaxial) of leaf. The stomata number on adaxial surface of leaf of *Ruellia tuberosa* was not significantly correlated with number of irrigation days either at pre- or post-flowering stage (Figure 36B and C). But, stronger correlation between stomata number (on adaxial leaf surface of *R. tuberosa*) and water treatment days was recorded in response to high moisture (W_1 and W_2) and low moisture (W_4 and W_5) levels. The degree of dependence of stomata number on moisture content was very high at post-flowering stage as compared to pre-flowering stage in *Ruellia tuberosa* (Figure 36A-C).

The correlation coefficients of stomatal index and stomata number vs days of moisture stress were almost similar but degree of dependence of stomatal index on longevity and level of watering were high (Figure 36A, B, D and E). In both the species. correlation coefficients between stomata number (on abaxial surface) and stress days were significantly high at low (W_3 and W_4) or high (W_1) moisture levels. But the correlation coefficient at W_3 water level was significantly negative on both the surfaces

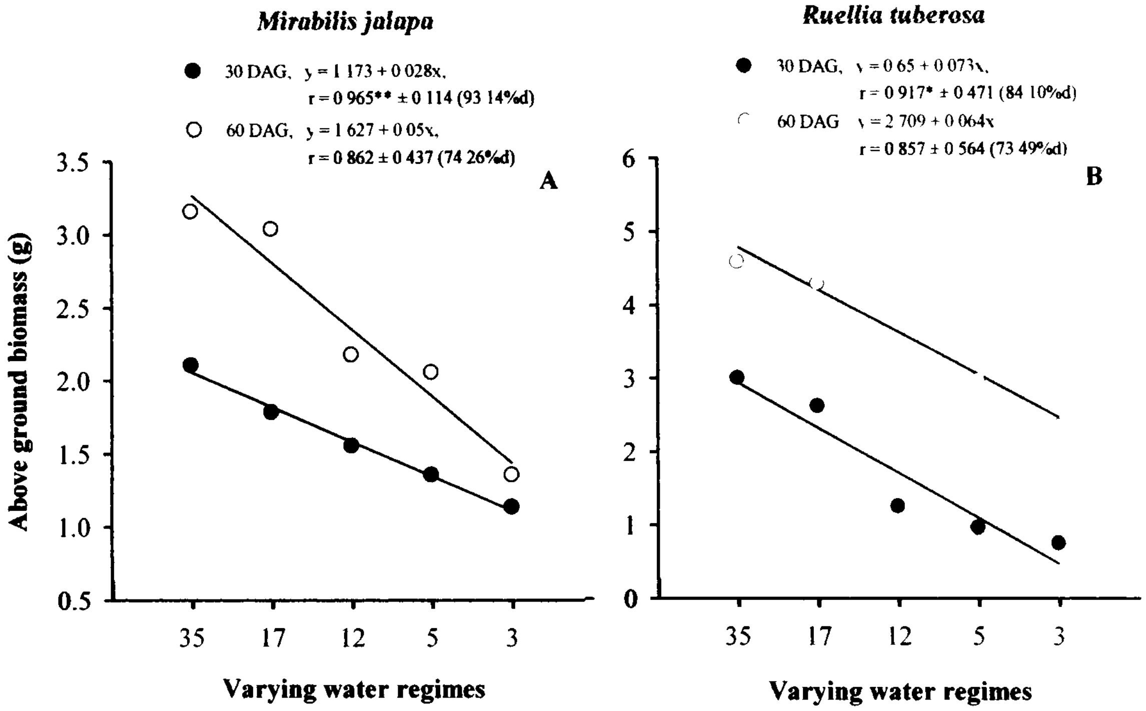


Figure 35. Regression line with the equation of y, correlation coefficient (r), ±SE(r), * significance and percent dependence (within parenthesis) of above ground biomass of selected species with respect to varying water stress days (W_1-W_5). (Data in annexed Table 36).

Plate 7

A, B, C, D and E – Leaf peal of abaxial surface of *Mirabilis jalapa* showing variable stomata number when treated with variable water levels at 60 days after germination.

F, G, H, I and J – Leaf peal of adaxial surface of *Ruellia tuberosa* showing variable stomata number when treated with variable water levels at 60 days after germination.

K, L, M, N and O – Leaf peal of abaxial surface of *Ruellia tuberosa* showing variable stomata number when treated with variable water levels at 60 days after germination.

P, Q, R, S and T – Visual effect of varying water regimes (W_1, W_2, W_3, W_4 and W_5) on the leaf tissues (palisade, spongy parenchyma, vascular area) of *Mirabilis jalapa* treated 60 days after germination.

U, V, W, X and Y – Visual effect of varying water regimes (W_1, W_2, W_3, W_4 and W_5) on the leaf tissues (palisade, spongy parenchyma, vascular area) of *Ruellia tuberosa* treated 60 days after germination.

Bars equal to 50µ (A to O) and 100µ (P to Y).

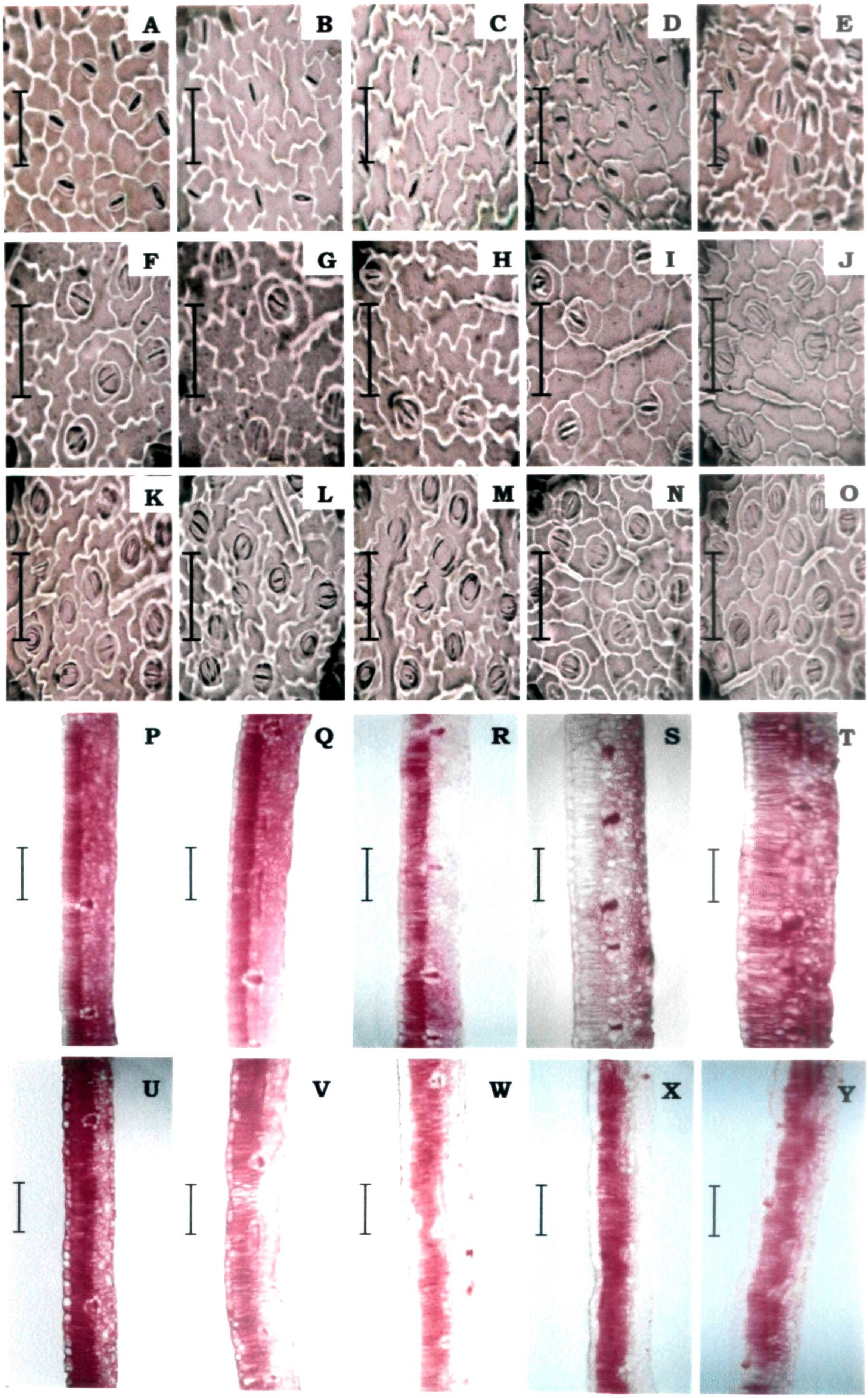


Plate 7

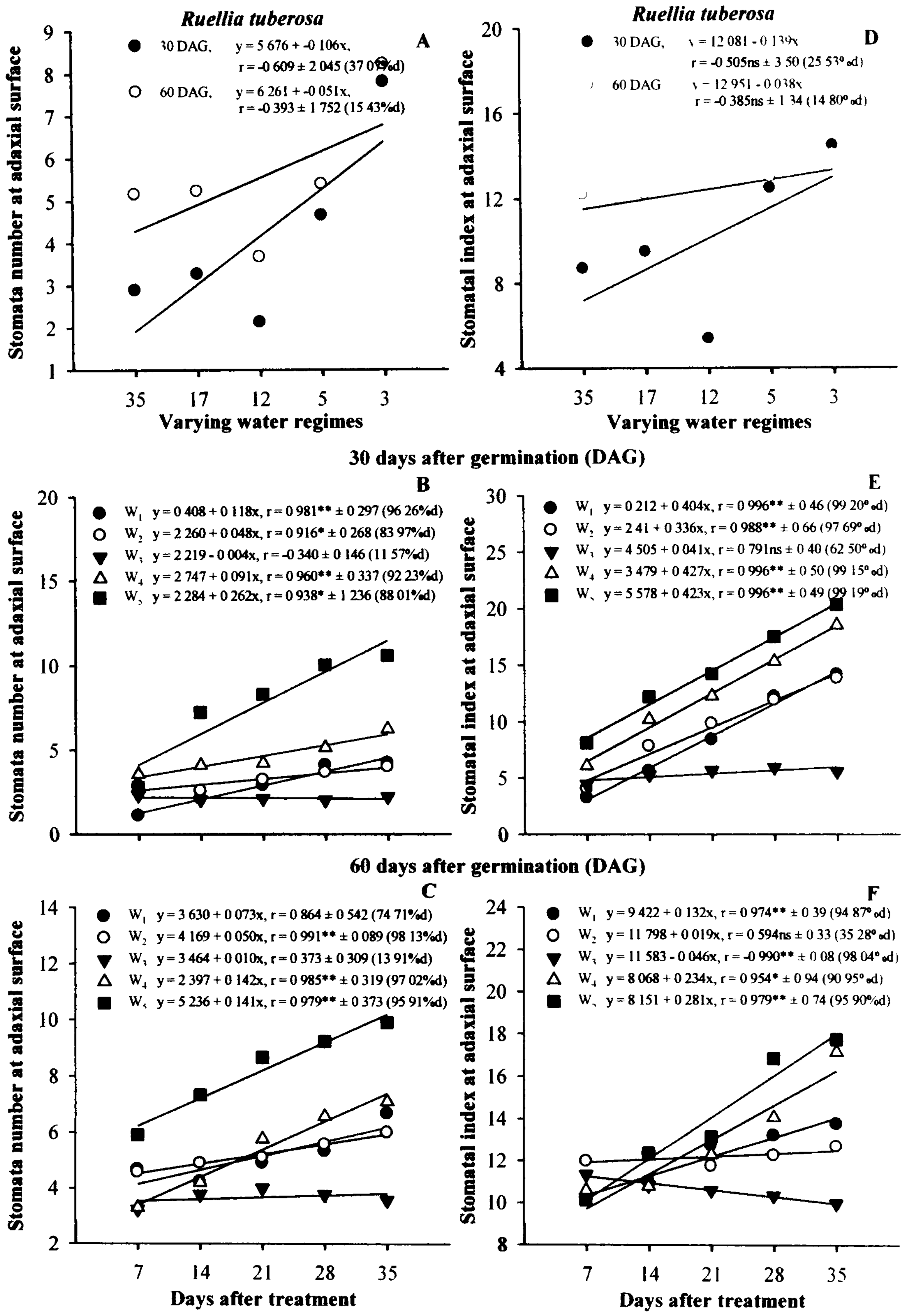


Figure 36. Regression line with the equation of y, correlation coefficient (r), ±SE(r), * significance and percent dependence (within parenthesis) of stomata number and index of adaxial surface of selected *Ruellia tuberosa* with respect to varying water stress days (W_1-W_5). (Data in annexed Table 37). Stomata were absent on adaxial surface of *Mirabilis jalapa*.

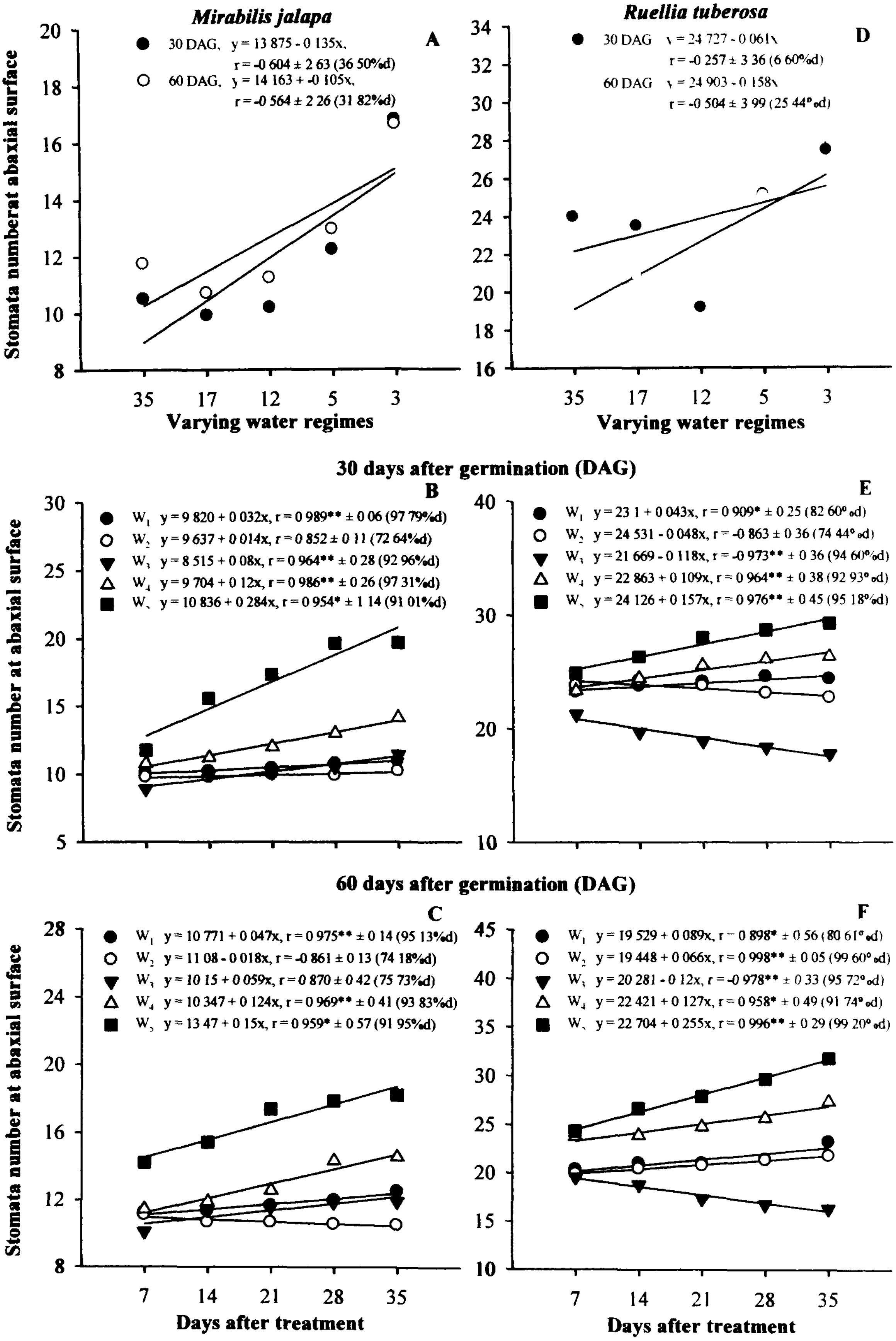


Figure 37. Regression line with the equation of y, correlation coefficient (r), ±SE(r), * significance and percent dependence (within parenthesis) of stomata number at abaxial surface of selected species with respect to varying water stress days (W_1-W_5). (Data in annexed Table 38).

of leaf of *R. tuberosa* at its pre-flowering or post-flowering stages (Figure 37 and 38). In *Mirabilis jalapa*, the stomata number on abaxial surface was relatively more strongly and positively correlated with stress days at low moisture (W_4 and W_5) levels (Figure 37). The steepness in the linear regression line (factor b of the equation) was greater at low moisture level in *Mirabilis jalapa* (Figure 36C).

The vascular area in the leaf of *Mirabilis jalapa* at pre- and post-flowering stages with the increase in water stress. The dermal system in well watered plants (W_1 and W_2) at both the stages was higher as compared to water stressed individuals. The dermal system consistently decreased with the increase in water stress (Figure 39). The proportion of palisade was high in water stressed (W_3, W_4 and W_5) individuals of *Mirabilis jalapa* at both pre- and post-flowering stage (Figure 39). The total leaf tissue area increased in water stressed (W_4 and W_5) plants of *Mirabilis jalapa* (Figure 39). The highest plasticity was recorded in the proportions of mesophyll and palisade layers in *Ruellia tuberosa* (Figure 39).

d) Reproductive growth

The trend of correlation coefficient, degree of dependence and linear regression between floral bud number and varying moisture level (Figure 40) in both the selected species resembled with the trend of leaf number. The span of low moisture at post-reproductive stage (in both the plants) reduced number of floral buds (due to reduced emergence and/or increased abortion). Low moisture content (W_4 and W_5) delayed emergence of floral buds and thus the stronger positive correlation between floral bud number and stress days were recorded in response to W_1, W_2, W_3 and W_4 watering level in *Ruellia tuberosa* (Figure 40E). At W_4 watering level, the floral buds emerged at pre-flowering stage of *Ruellia tuberosa* got aborted (Figure 40E). The regression line

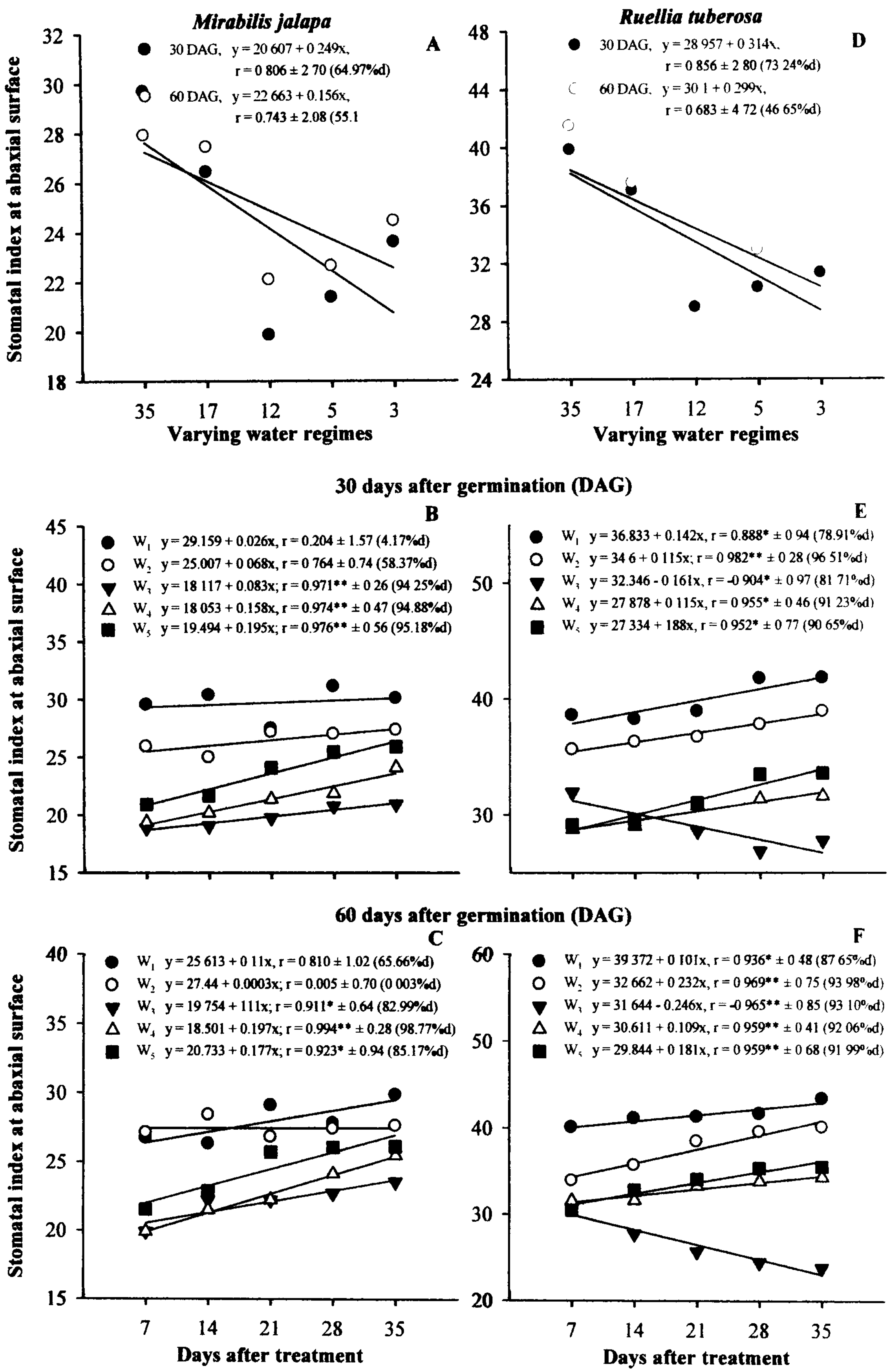


Figure 38. Regression line with the equation of y, correlation coefficient (r), ±SE(r), * significance and percent dependence (within parenthesis) of stomatal index at abaxial surface of selected species with respect to varying water stress days (W_1-W_5). (Data in annexed Table 39).

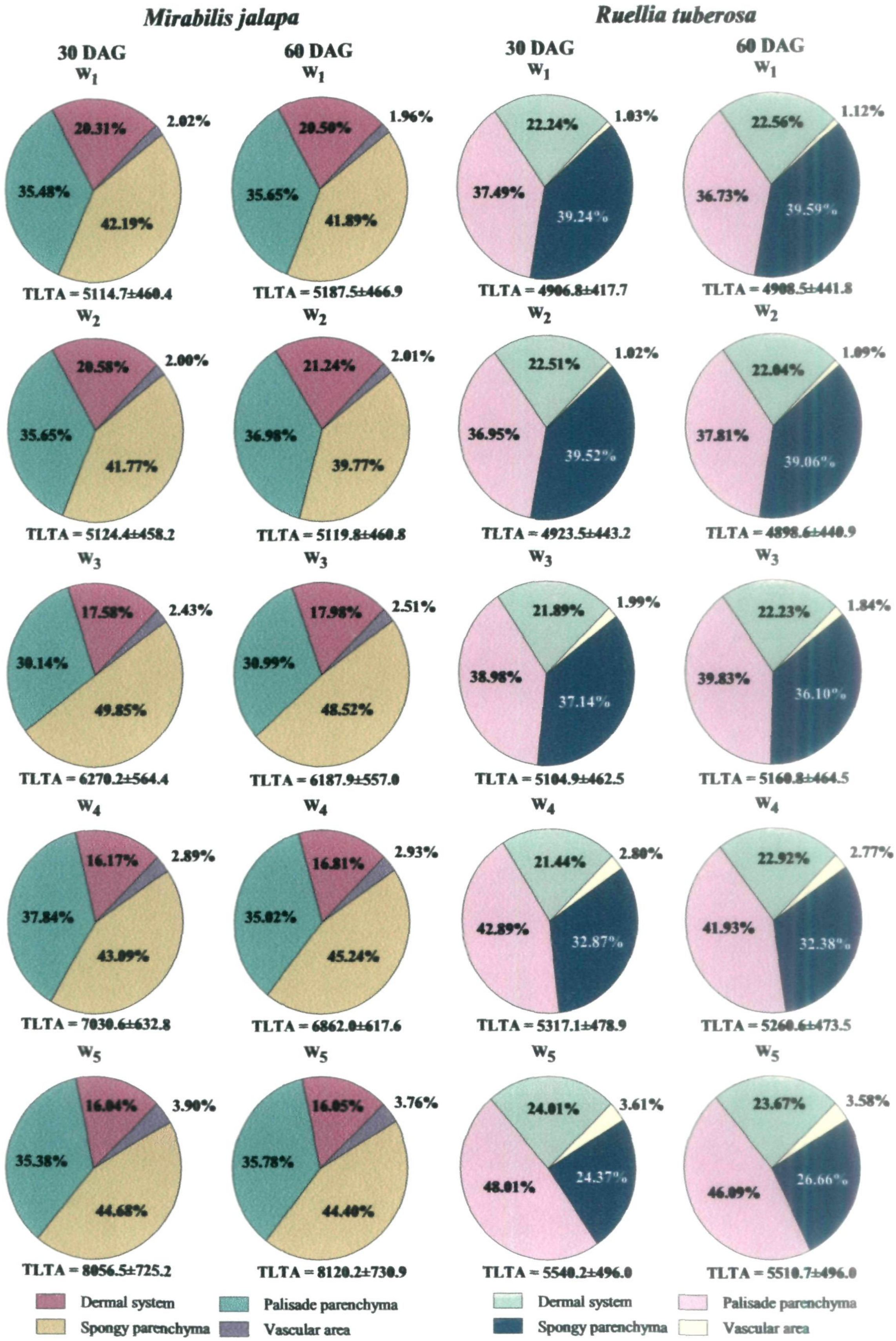


Figure 39. Relative proportion of leaf tissue systems of selected plants with respect to varying water stress (W_1 - W_5). (Data in annexed Table 40).
Mean±SD, TLTA-Total leaf tissue area.

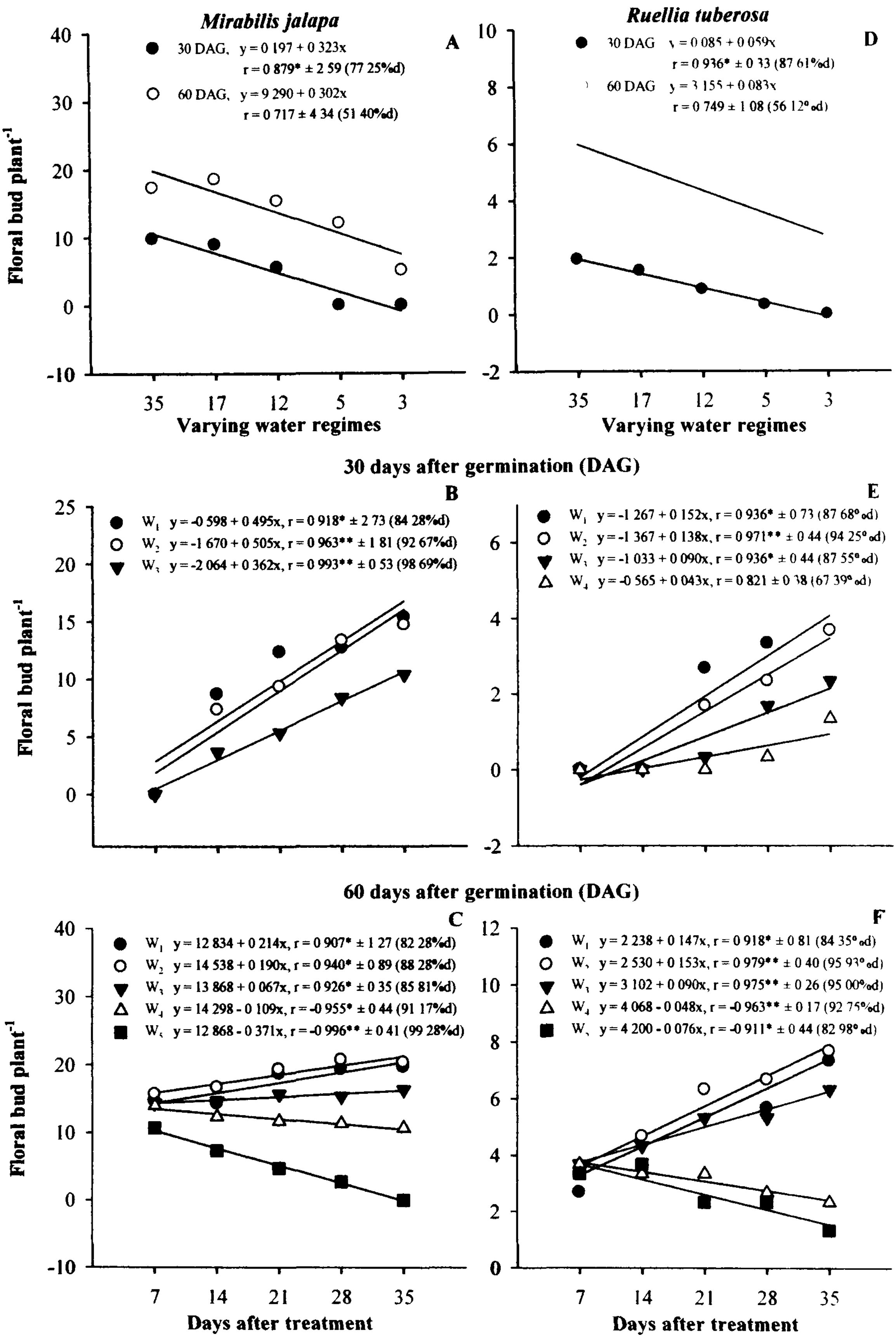


Figure 40. Regression line with the equation of y, correlation coefficient (r), ±SE(r), * significance and percent dependence (within parenthesis) of floral bud plant^{-1} of selected species with respect to varying water stress days (W_1-W_5). No budding was recorded in response to W_4 and W_5 (B) and W_5 (E). (Data in annexed Table 41).

between flower and fruit number and water stress resembled more or less with each other in the patterns and degree (Figure 41 and 42).

The correlation coefficient between average seed output with respect to varying water regimes had relatively greater degree of positive correlation in *Mirabilis jalapa* than *Ruellia tuberosa* (Figure 43A and C). High moisture level (W_1, W_2 and W_3) led to stronger positive correlation bonds between average seed output and span of moisture stress in *Mirabilis jalapa*. But average seed output had a stronger negative correlation with respect to span of water stress in *M. jalapa* and *R. tuberosa* at W_5 watering level (Figure 43B and D). In *Ruellia tuberosa* W_1 and W_2 did not show stronger bonds between average seed output and moisture longevity indicating that daily and alternate day watering maintained the average seed output from 7 to 35 days stage (Figure 43D).

Effect of varying light regimes

a) Vegetative growth

Both the selected species were grown under three light regimes viz, open light (1550 – 1498Lux), partial shade (1249 – 1195Lux) and shade (466 – 451Lux) and their vegetative and reproductive performances were recorded. The shade led to etiolated growth in *Mirabilis jalapa* at pre-flowering stage but not at post-flowering stage (Figure 44B). The plant height of *Ruellia tuberosa* grown under partial shade was better than the individuals grown either under open light or shade. The plant height of *Ruellia tuberosa* increased significantly under partial shade both at pre- and post-flowering stages (Figure 44D, E and F).

The leaf number in *Mirabilis jalapa* and *Ruellia tuberosa* increased under open light (Figure 45A and D) when exposed for 5 weeks at post-flowering stage (Figure 45C and E). Partial light at pre- and post-flowering stages increased the leaf number in

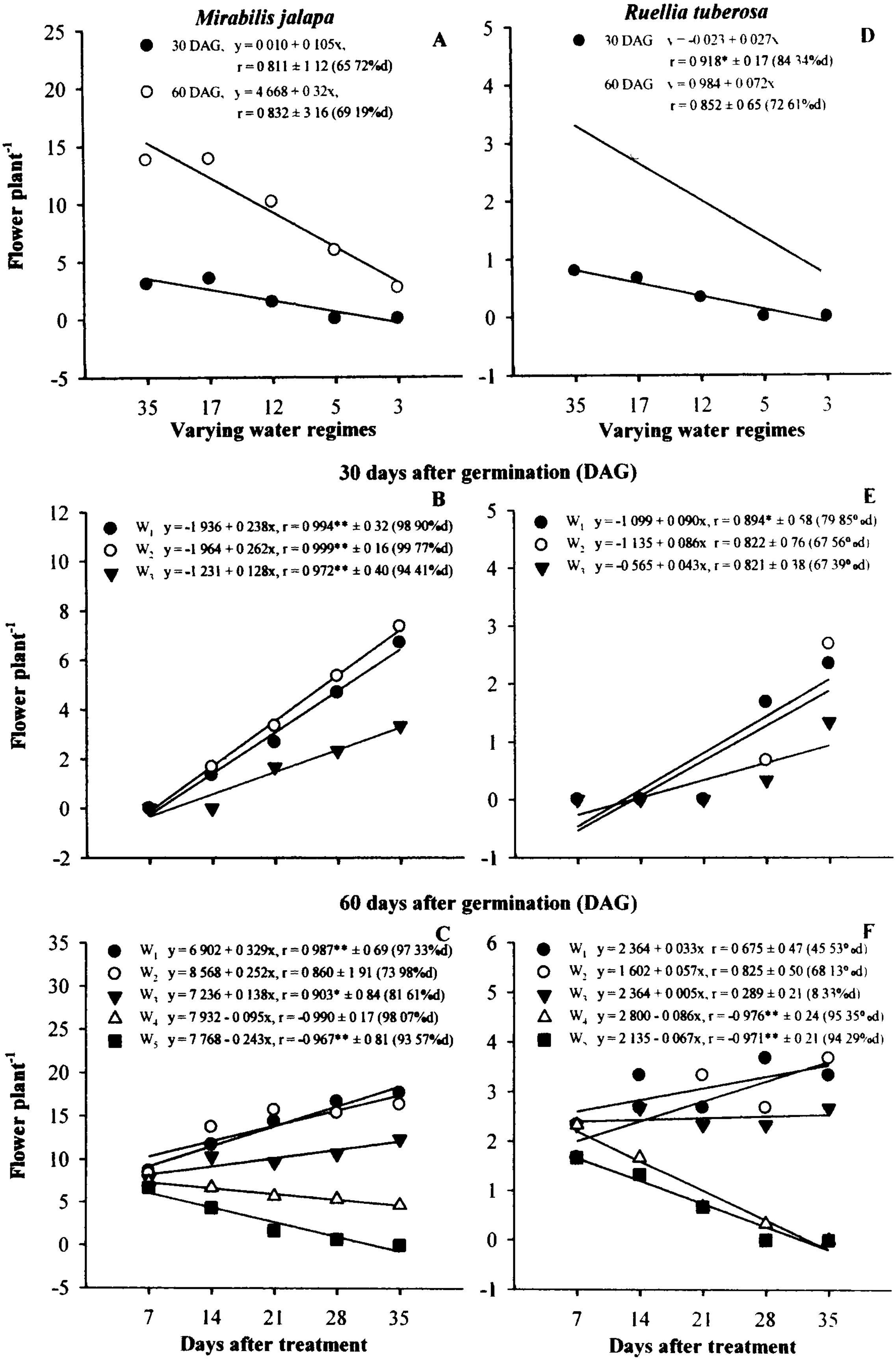


Figure 41. Regression line with the equation of y, correlation coefficient (r), ±SE(r), * significance and percent dependence (within parenthesis) of flower plant^{-1} of selected species with respect to varying water stress days (W_1-W_5). No flowering was recorded in response to W_4 and W_5 (B and E). (Data in annexed Table 42).

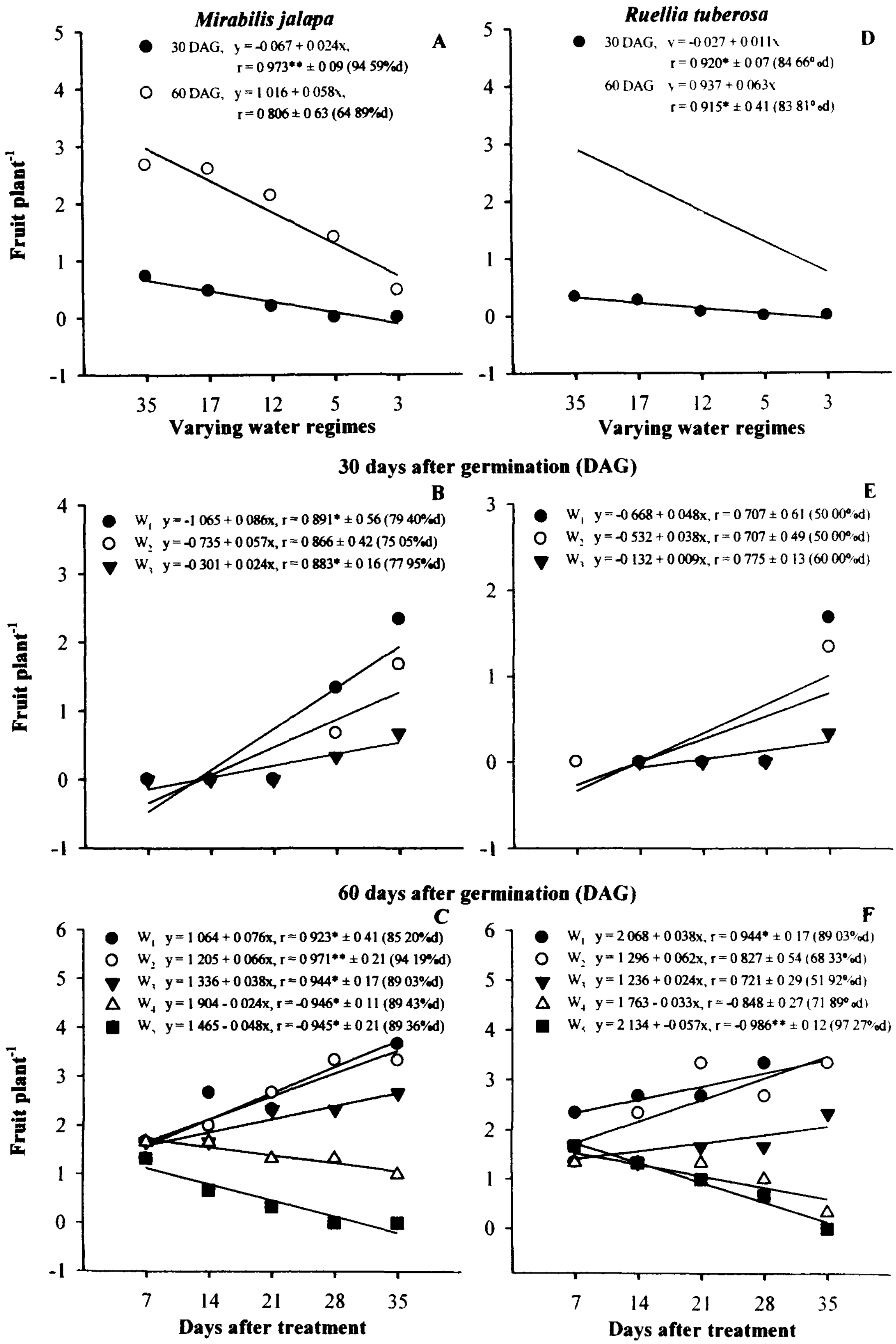


Figure 42. Regression line with the equation of y, correlation coefficient (r), ±SE(r), * significance and percent dependence (within parenthesis) of fruit plant^{-1} of selected species with respect to varying water stress days (W_1-W_5). No fruiting was recorded in response to W_4 and W_5 (B and E). (Data in annexed Table 43).

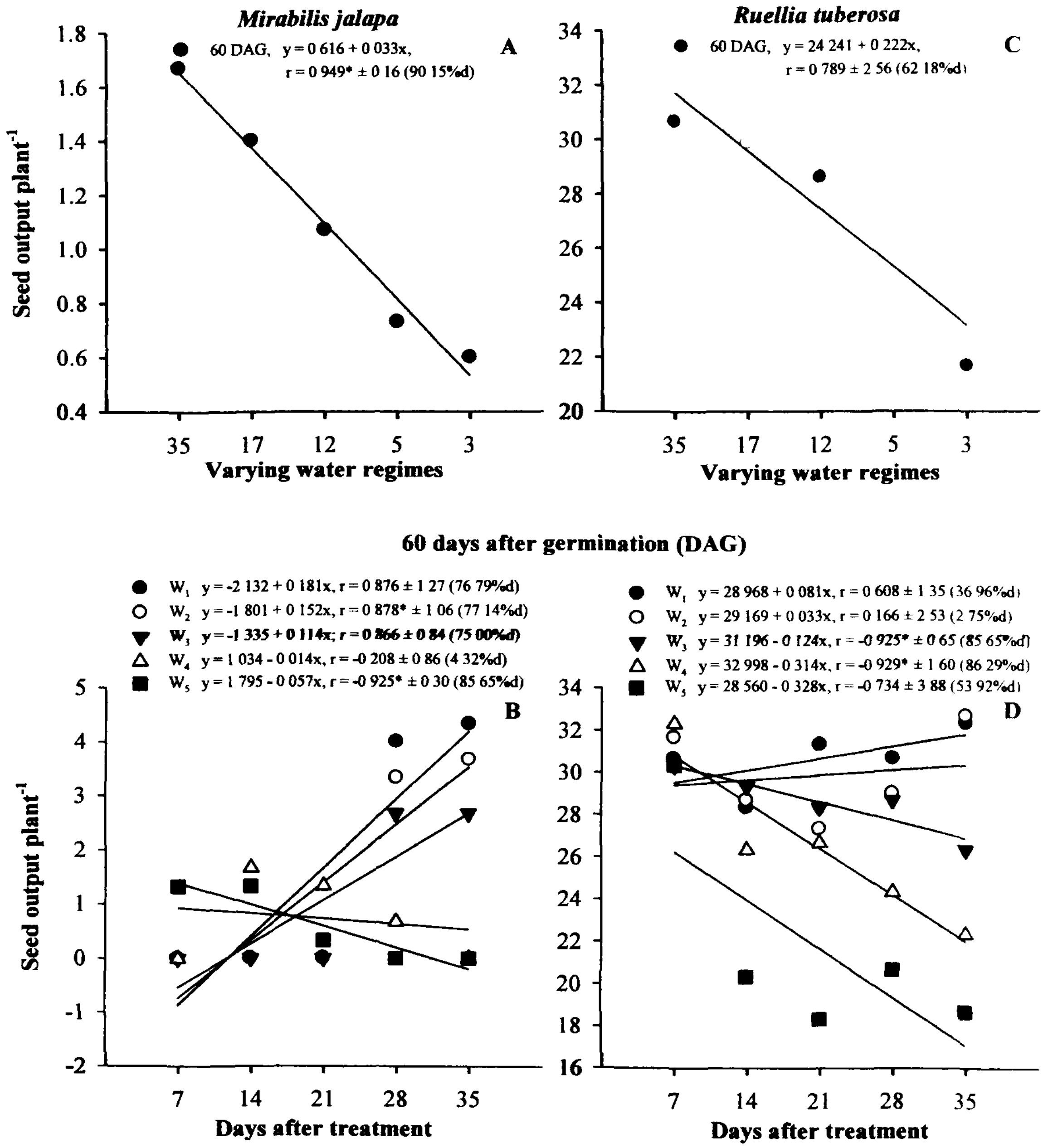


Figure 43. Regression line with the equation of y, correlation coefficient (r), ±SE(r), * significance and percent dependence (within parenthesis) of seed output plant^{-1} of selected species with respect to varying water stress days (W_1-W_5). Seed setting was recorded at the stage of 30 days after germination. (Data in annexed Table 44).

Plate 8

A – Visual effect of varying luminance (open, partial shade and shade) on the growth of 60 days old *Mirabilis jalapa*.

B – Visual effect of varying luminance (open, partial shade and shade) on the growth of 60 days old *Ruellia tuberosa*.

Bars equal to 100mm.

Plate 8

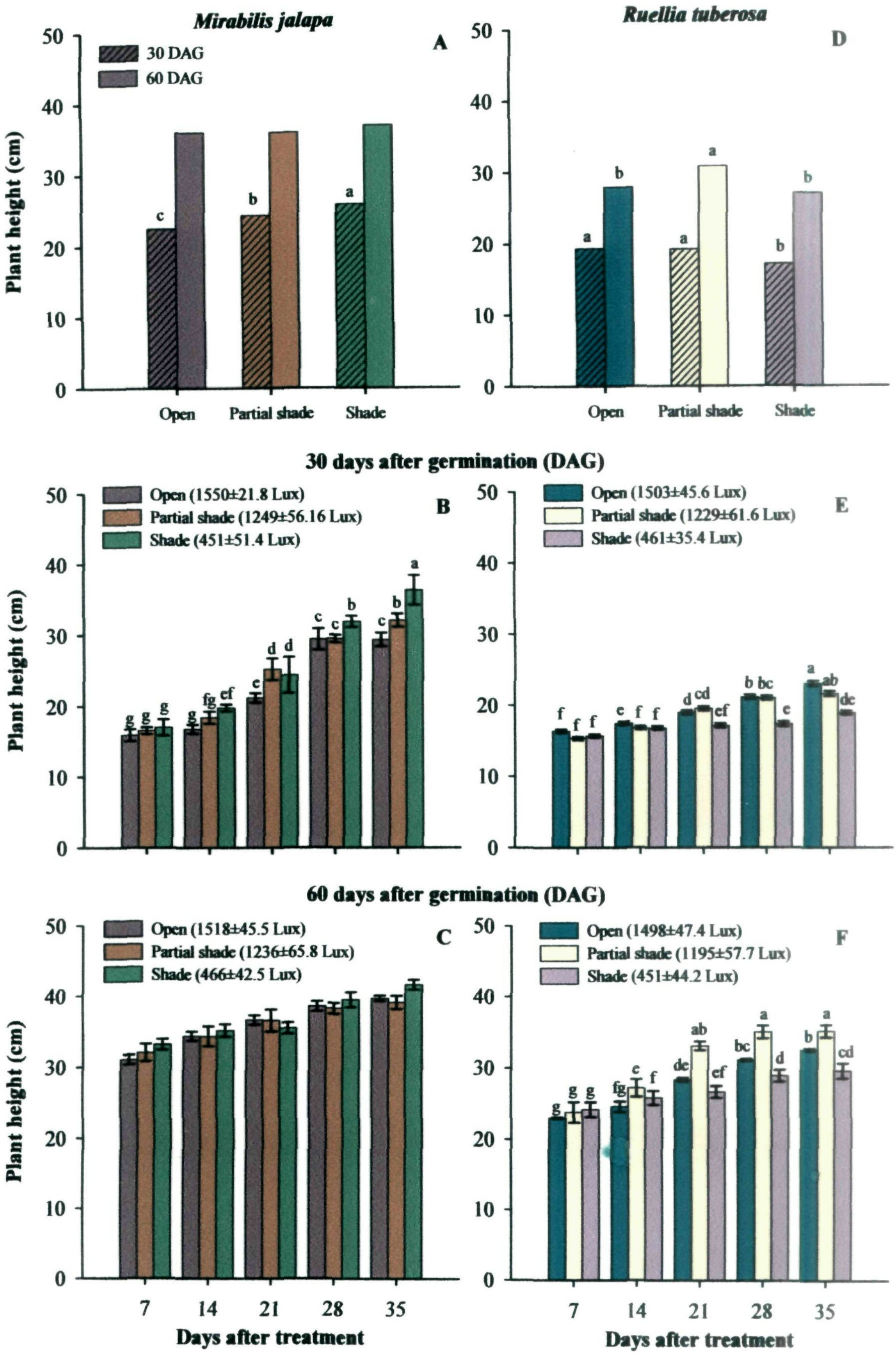


Figure 44. Effect of varying luminance on the height of selected species (Mean±SE) exposed at 30 days and 60 days (pre-flowering and post-flowering stages) for 5 weeks. Bars signified with common alphabets shows non-significant difference. (Data in annexed Table 45).

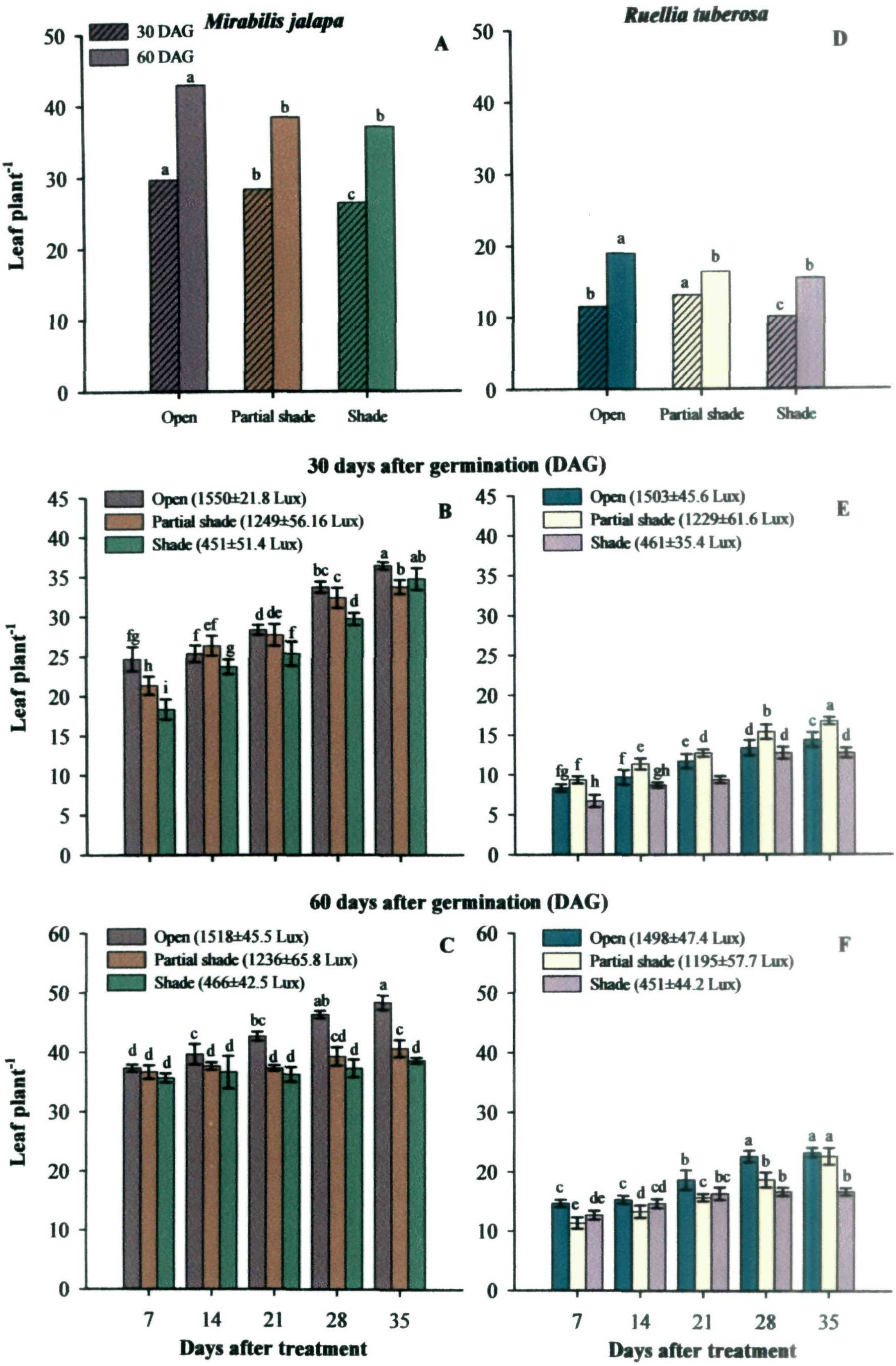


Figure 45. Effect of varying luminance on the leaf plant^{-1} of selected species (Mean±SE) exposed at 30 days and 60 days (pre-flowering and post-flowering stages) for 5 weeks. Bars signified with common alphabets shows non-significant difference. (Data in annexed Table 46).

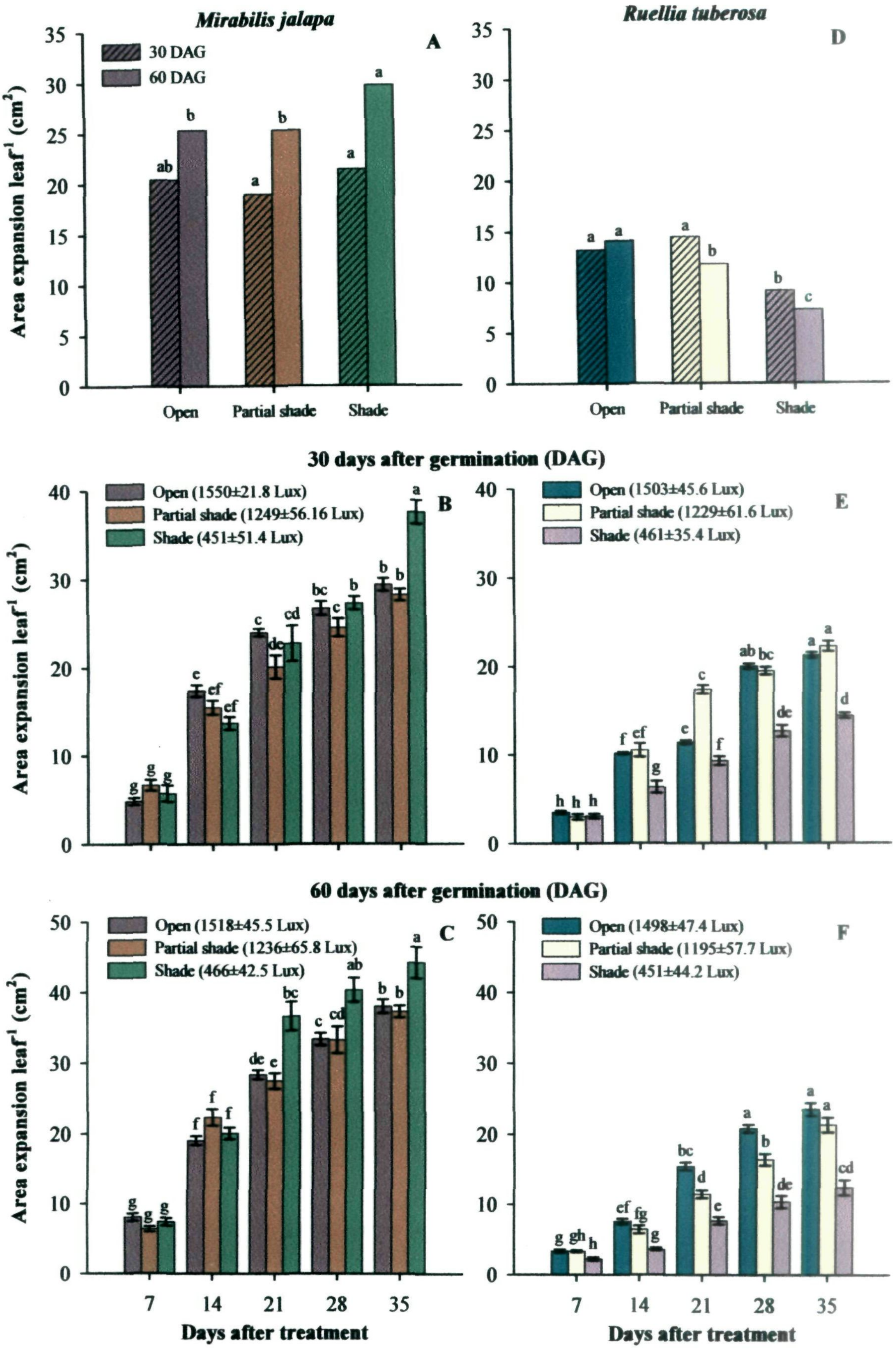


Figure 46. Effect of varying luminance on the area expansion leaf^{-1} of selected species (Mean±SE) exposed at 30 days and 60 days (pre-flowering and post-flowering stages) for 5 weeks. Bars signified with common alphabets shows non-significant difference. (Data in annexed Table 47).

Ruellia tuberosa (Figure 45D). In *Mirabilis jalapa*, the partial light increased leaf number only at pre-flowering stage but not at post-flowering stage (Figure 45B and C). In *Ruellia tuberosa*, the impact of light variation on leaf number both at pre- and post-flowering stages was significant on prolong exposure up to 28-35 days (Figure 45E and F).

The leaf area of *Mirabilis jalapa* was sensitive to varying light regimes both at pre- and post-flowering stages. Long term exposure to shade increased leaf area of *Mirabilis jalapa* (Figure 46B and C). The leaves of *Ruellia tuberosa* expanded well under open and partial shade (Figure 46D). The leaf expansion was more prominent under open light at pre-flowering stage of *Ruellia tuberosa* (Figure 46E). At post-flowering stage, the leaf expansion of *Ruellia tuberosa* was better on long term exposure to open light extending from 28 to 35 days (Figure 46F).

b) Physio-biochemical variations

The relative water content (RWC) in the leaf tissues did not show significant change in response to luminance variation in both the species either exposed at pre- or post-flowering stage (Figure 47). The chlorophyll-a content also followed similar trend (Figure 48). Chlorophyll-b in *Mirabilis jalapa* was relatively high under shade and partial shade than under open light (Figure 49A). The plants of *Ruellia tuberosa* and *Mirabilis jalapa* kept under shade at post-flowering stage had slightly high chlorophyll-b content (Figure 49C and F). The total chlorophyll content in both the species was marginally high under shade than under open light or partial shade (Figure 50). The above ground biomass in both the species was high under open light followed by partial shade and shades at pre- and post-flowering stage (Figure 51).

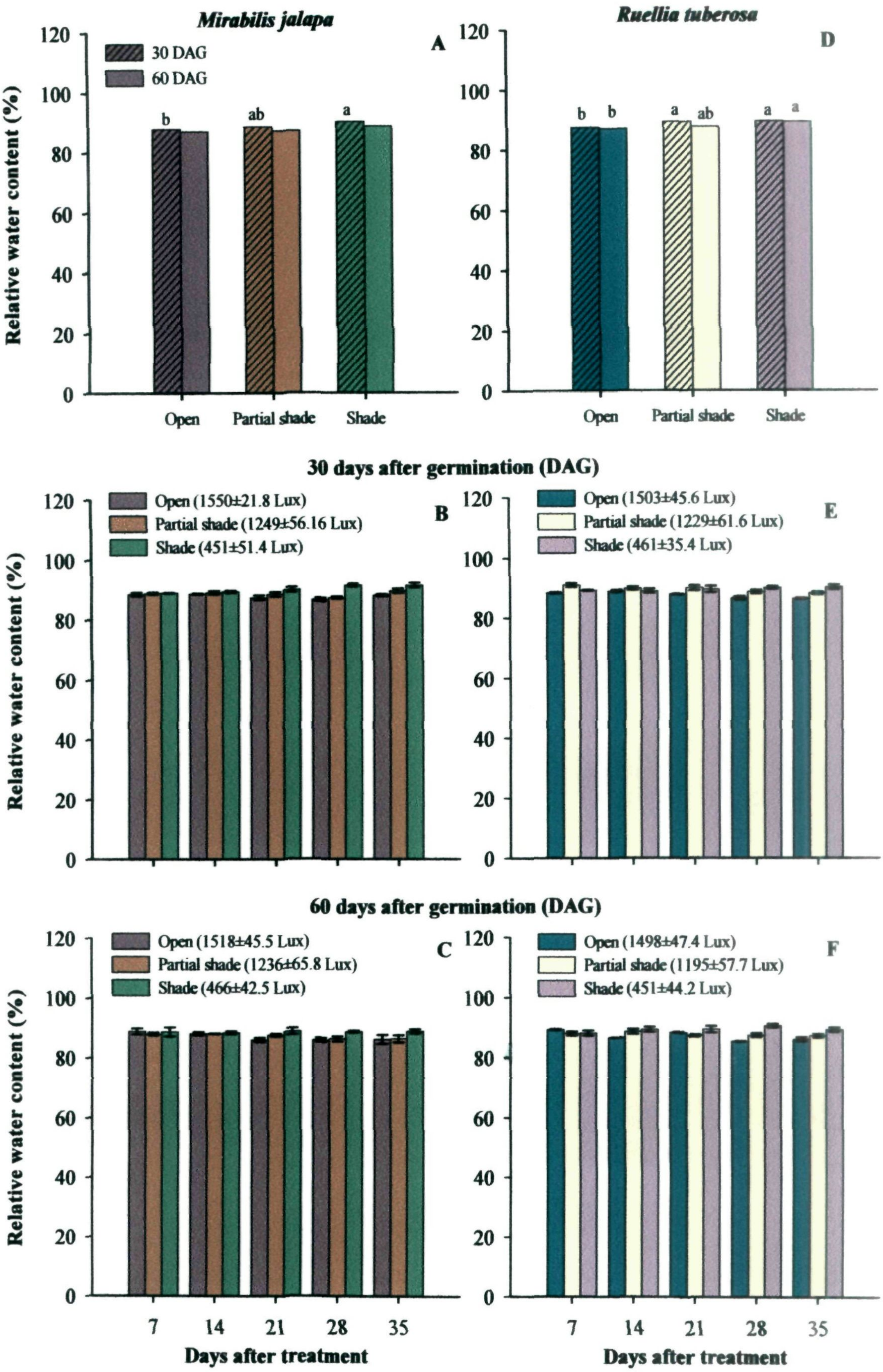


Figure 47. Effect of varying luminance on the relative water content of selected species (Mean±SE) exposed at 30 days and 60 days (pre-flowering and post-flowering stages) for 5 weeks. Bars signified with common alphabets shows non-significant difference. (Data in annexed Table 48).

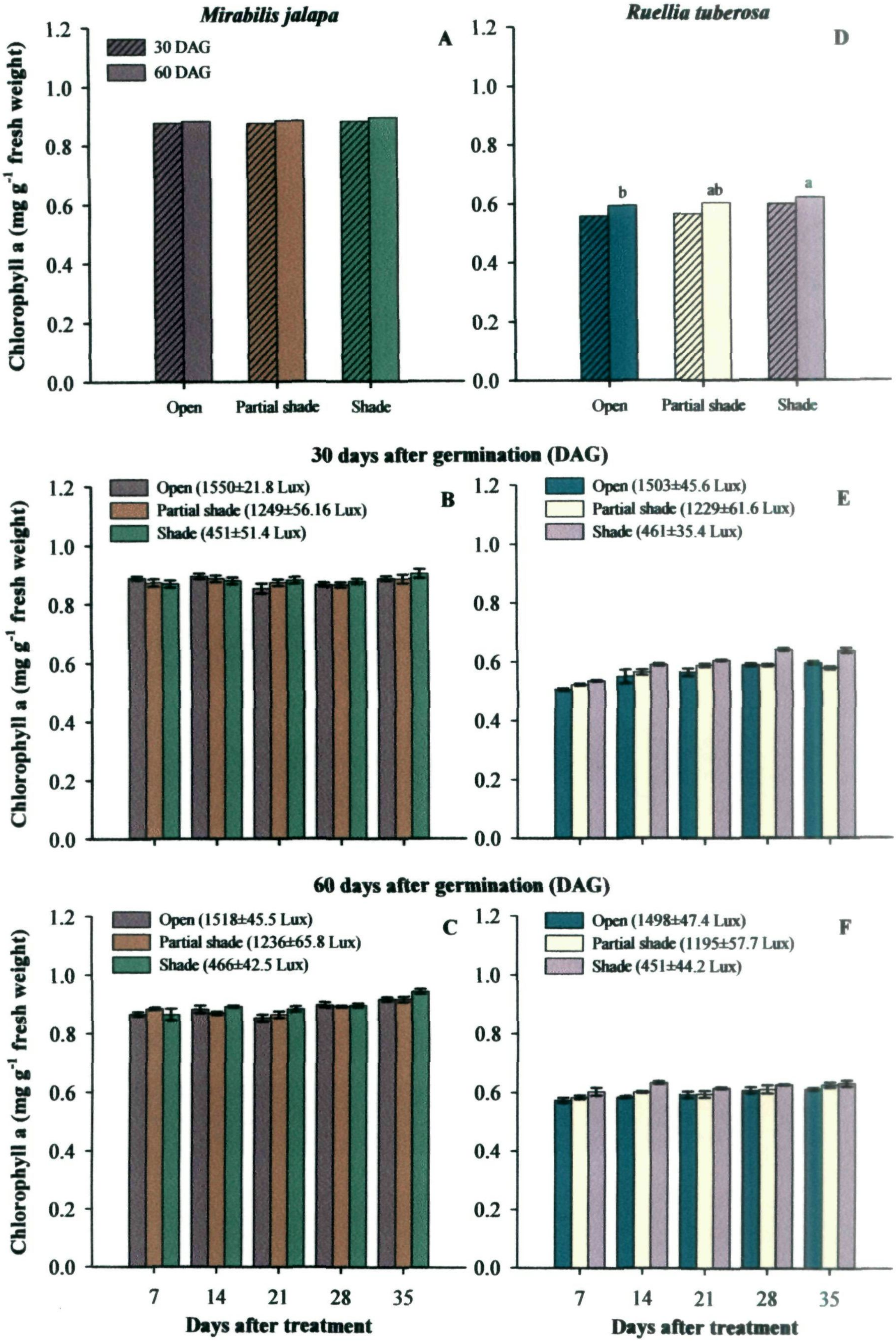


Figure 48. Effect of varying luminance on the chlorophyll a of selected species (Mean ± SE) exposed at 30 days and 60 days (pre-flowering and post-flowering stages) for 5 weeks. Bars signified with common alphabets shows non-significant difference. (Data in annexed Table 49).

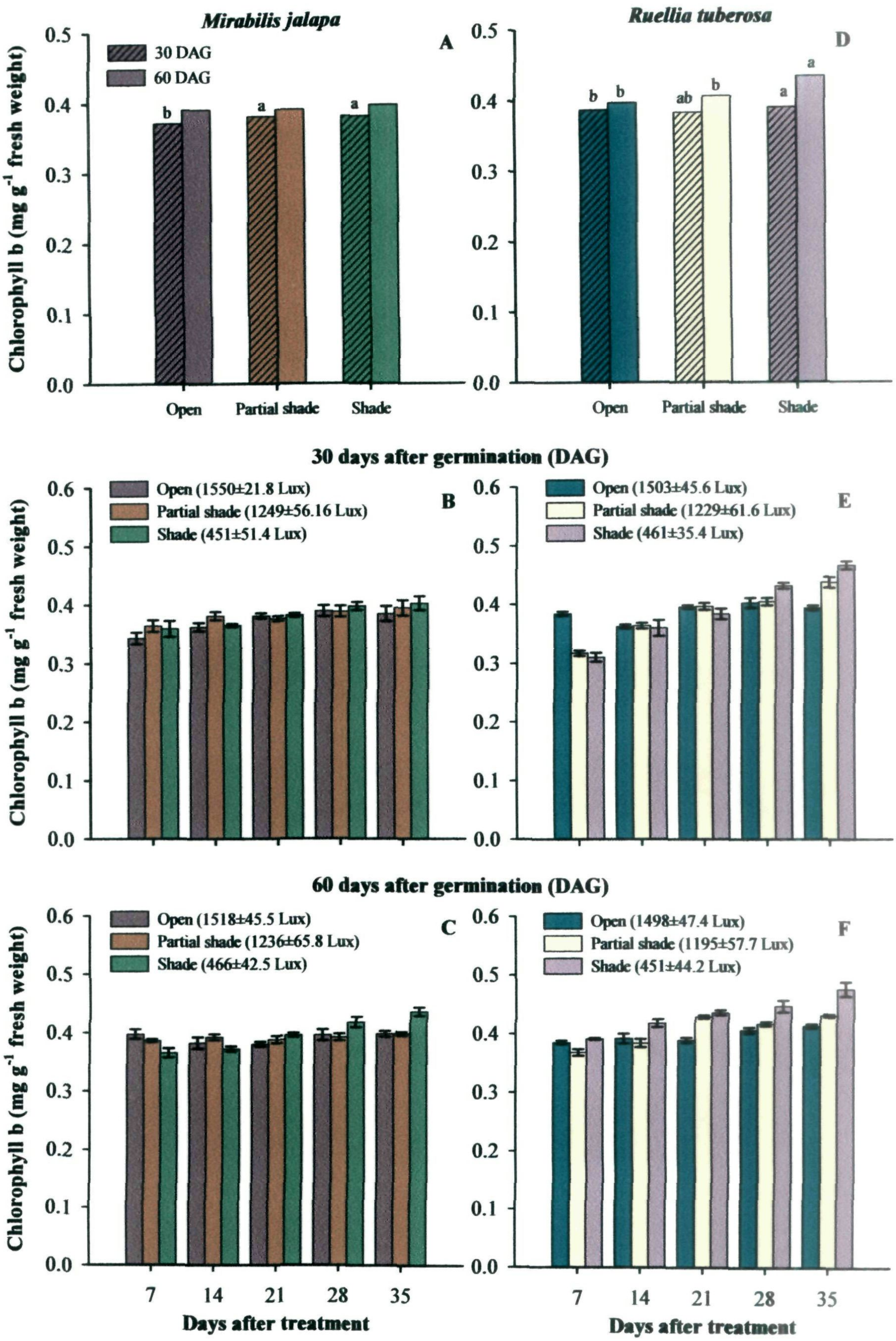


Figure 49. Effect of varying luminance on the chlorophyll b of selected species (Mean ± SE) exposed at 30 days and 60 days (pre-flowering and post-flowering stages) for 5 weeks. Bars signified with common alphabets shows non-significant difference. (Data in annexed Table 50).

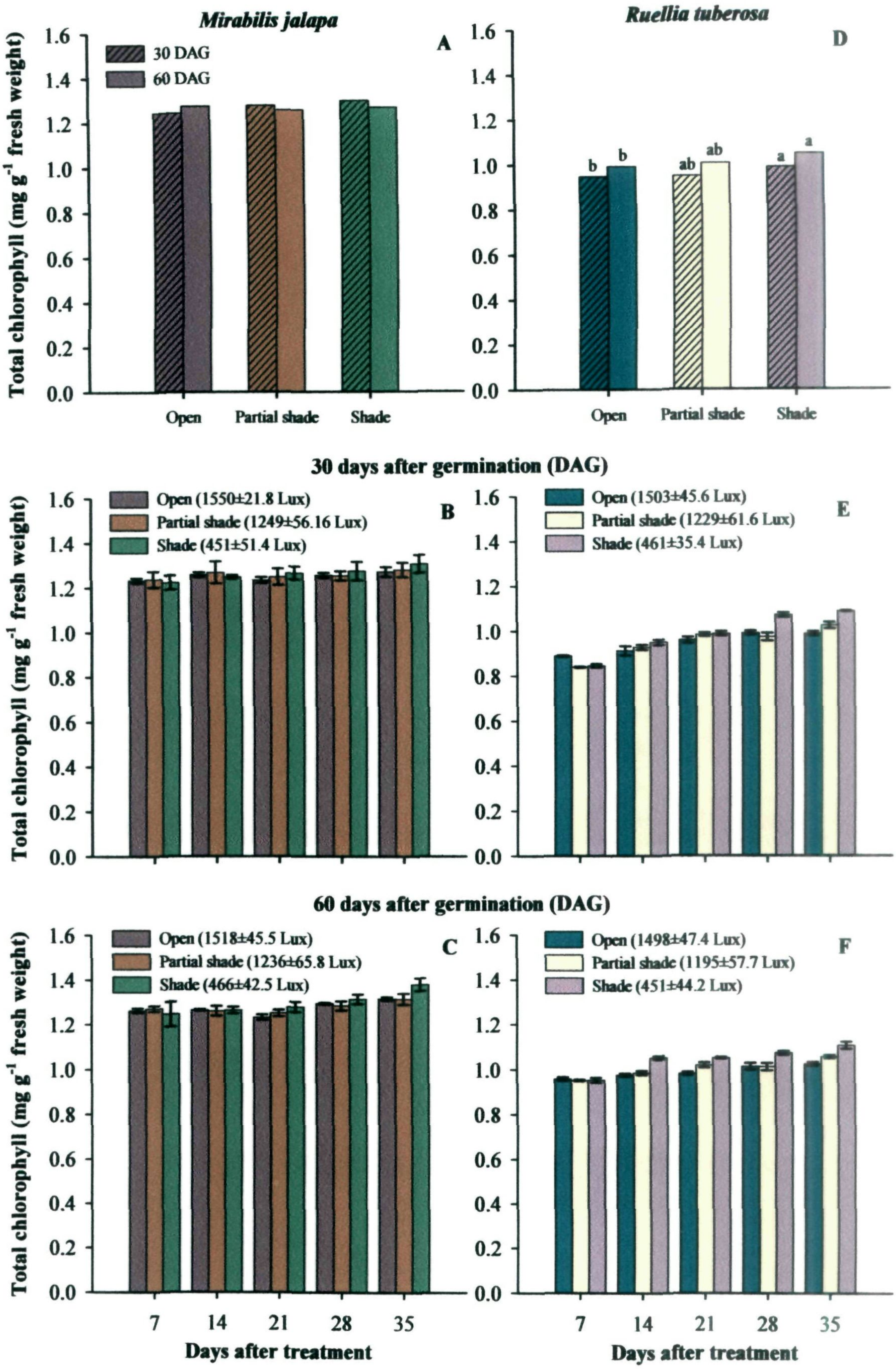


Figure 50. Effect of varying luminance on the total chlorophyll of selected species (Mean ± SE) exposed at 30 days and 60 days (pre-flowering and post-flowering stages) for 5 weeks. Bars signified with common alphabets shows non-significant difference. (Data in annexed Table 51).

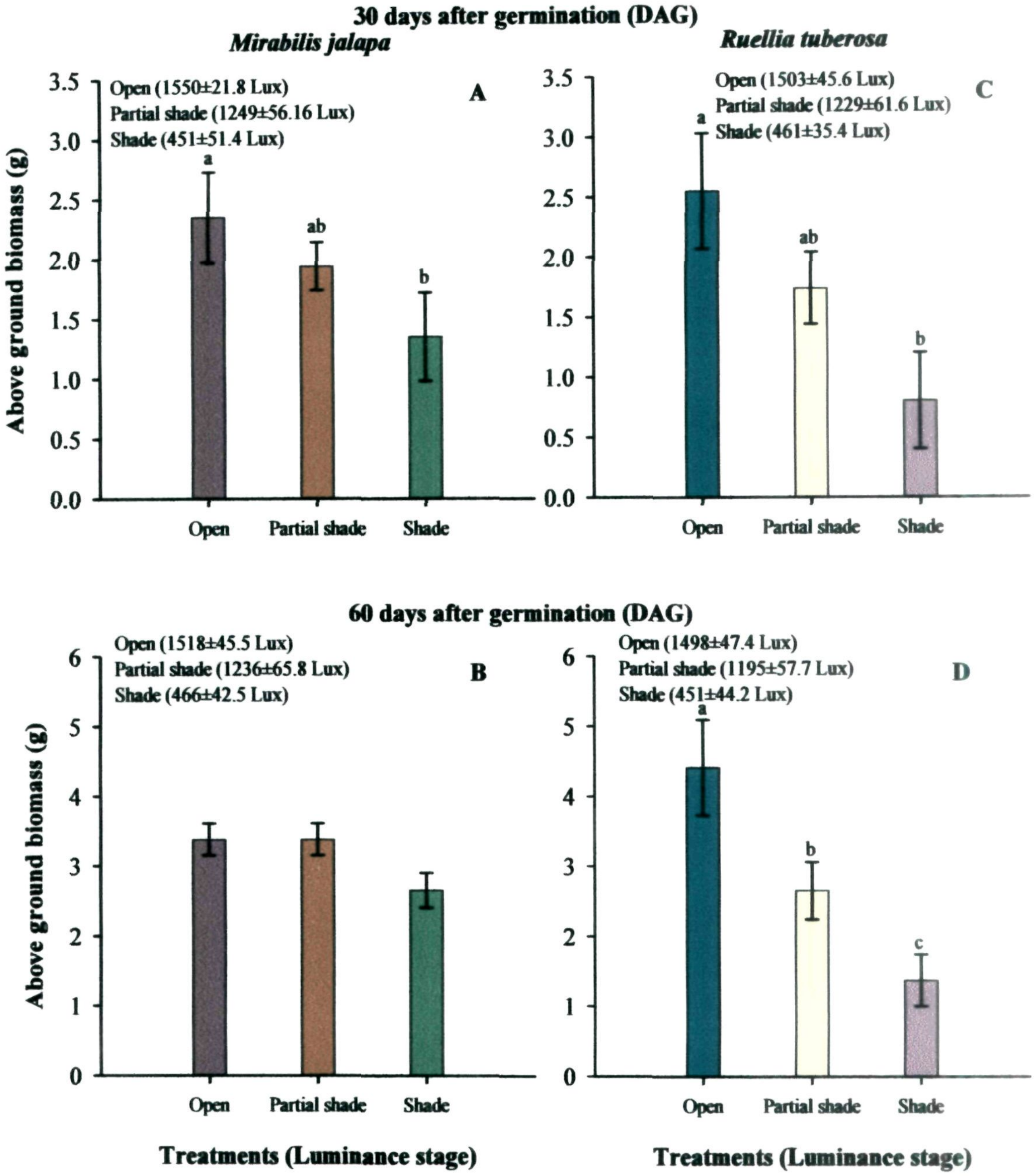


Figure 51. Effect of varying luminance on the above ground biomass of selected species (Mean ± SE) exposed at 30 days and 60 days (pre-flowering and post-flowering stages) for 5 weeks. Bars signified with common alphabets shows non-significant difference. (Data in annexed Table 52).

c) Histological variations

The stomata number and distribution in *Mirabilis jalapa* appeared to be highly related with light regime rather than water availability (Figure 52A-F and 38). The stomata number on adaxial leaf surface of *Mirabilis jalapa* was high under shade regime at pre- and post-flowering stages (Figure 52B and C). The stomata were absent on adaxial surface of *Mirabilis jalapa* kept under open light (Figure 52A). In *Ruellia tuberosa*, the stomata number was highest under open light as compared to partial shade or shade at pre- and post-flowering stages (Figure 52D). The shade enhanced the stomata number on the adaxial surface of leaf of *Mirabilis jalapa* within 21 days at pre-flowering stage and 14 days at post-flowering stage (Figure 52B and C). In *Ruellia tuberosa*, the stomata number increased under open light at pre- or post-flowering stages (Figure 52D). The stomata number on adaxial surface of *Ruellia tuberosa* remained significantly high under partial shade (Figure 52E and F). Stomata number on the abaxial surface of *Mirabilis jalapa* increased with shading effect (Figure 53A). But, in contrary, the stomata number on abaxial surface of *Ruellia tuberosa* decreased with the shading effect (Figure 53A and D). The stomata number on abaxial surface of *Mirabilis jalapa* was highest in the plants kept under shade either at pre- or post-flowering stages (Figure 53A, B and C). The open light enhanced stomata number on abaxial surface of leaf of *Ruellia tuberosa* both at pre- and post-flowering stages (Figure 53E and F). The stomatal indices of adaxial and abaxial surfaces followed the trend of stomata number in both the species (Figure 54 and 55).

In shade, the total leaf tissue area reduced in both the selected plants (Figure 56). The vascular area in both the plants at both the stages was higher under open light and partial shade as compared to the plants kept under shade. The proportion of dermal system in *Ruellia tuberosa* was higher in plants kept under shade at both the growth

Plate 9

A, B and C – Leaf peal of adaxial surface of *Mirabilis jalapa* (treated 60 days after germination) showing absence of stomata in open light (A) and presence of stomata under partial shade and shade (B and C).

D, E and F – Leaf peal of abaxial surface of *Mirabilis jalapa* (treated 60 days after germination) showing variable stomata number in open light (D), partial shade and shade (E and F).

G, H and I – Leaf peal of adaxial surface of *Ruellia tuberosa* (treated 60 days after germination) showing variable stomata number in open light (G), partial shade and shade (H and I).

J, K and L – Leaf peal of abaxial surface of *Ruellia tuberosa* (treated 60 days after germination) showing variable stomata number in open light (J), partial shade and shade (K and L).

M, N and O – Visual effect of varying luminance (open, partial shade and shade) on the leaf tissues (palisade, spongy parenchyma, vascular area) of *Mirabilis jalapa* exposed 60 days after germination.

P, Q and R – Visual effect of varying luminance (open, partial shade and shade) on the leaf tissues (palisade, spongy parenchyma, vascular area) of *Ruellia tuberosa* exposed 60 days after germination.

Bars equal to 50µ (A to L) and 100µ (M to R).

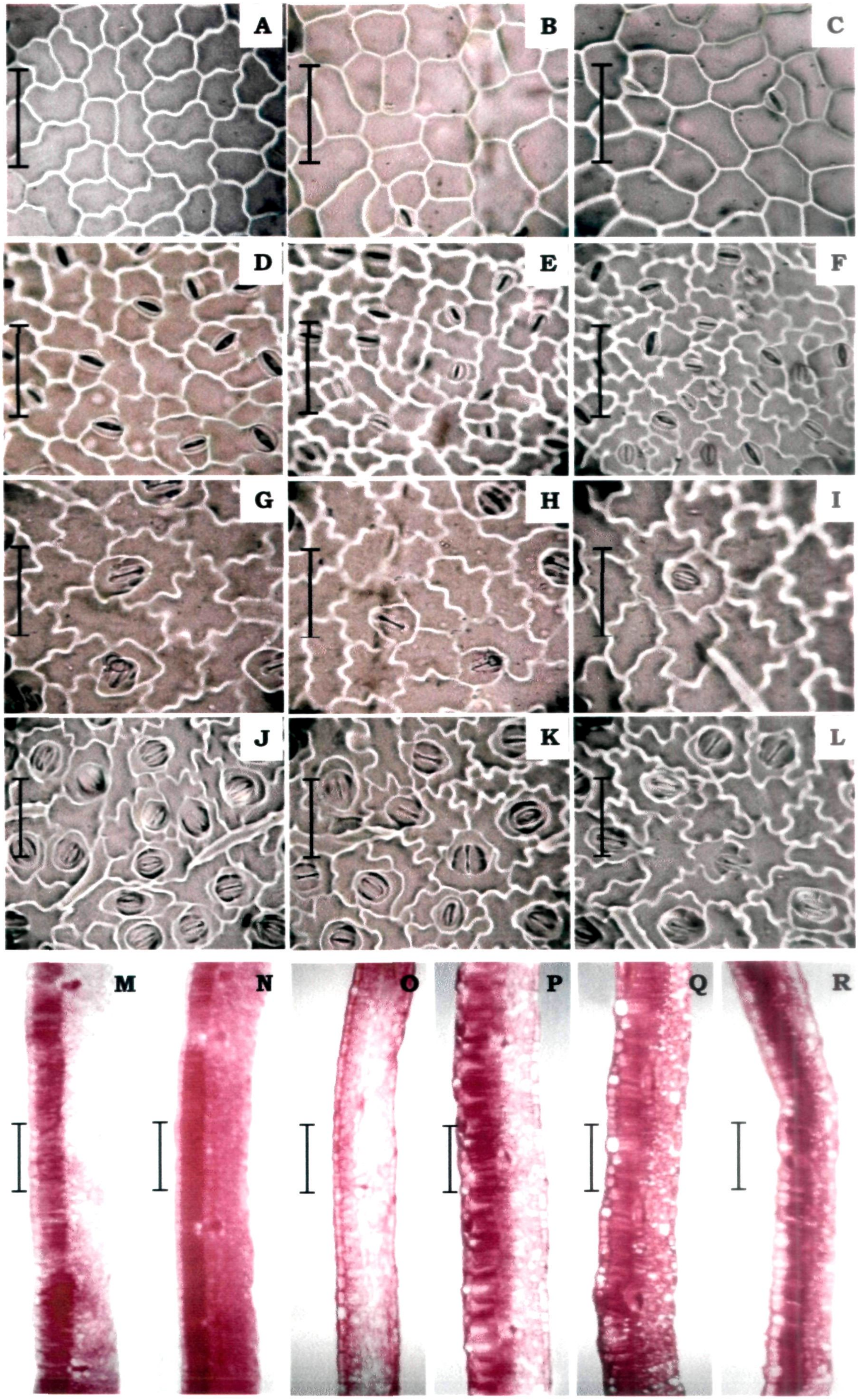


Plate 9

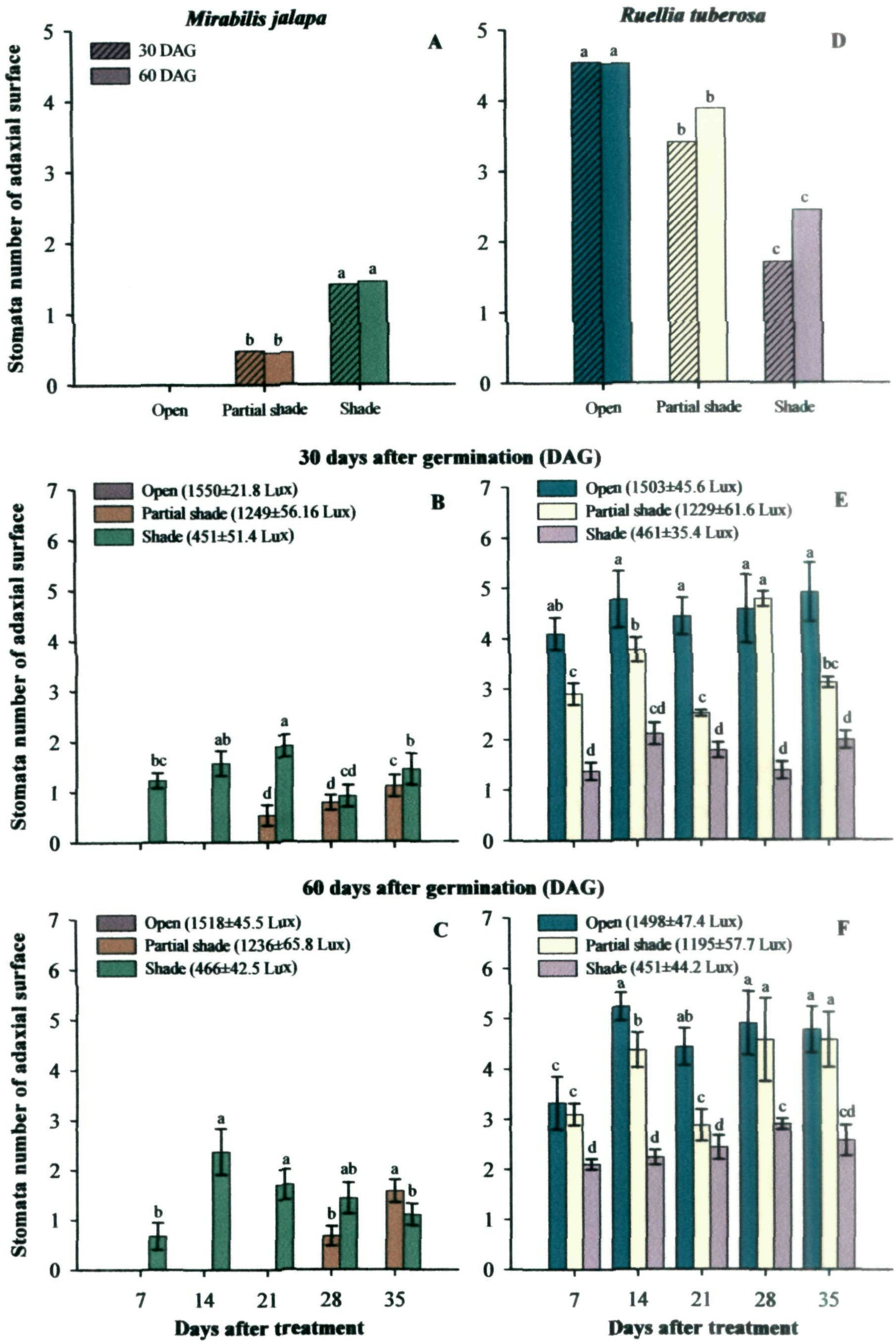


Figure 52. Effect of varying luminance on the stomata number of adaxial surface of selected species (Mean ± SE) exposed at 30 days and 60 days (pre-flowering and post-flowering stages) for 5 weeks. Stomata were absent in open light in *Mirabilis jalapa* (B and C). Bars signified with common alphabets shows non-significant difference. (Data in annexed Table 53).

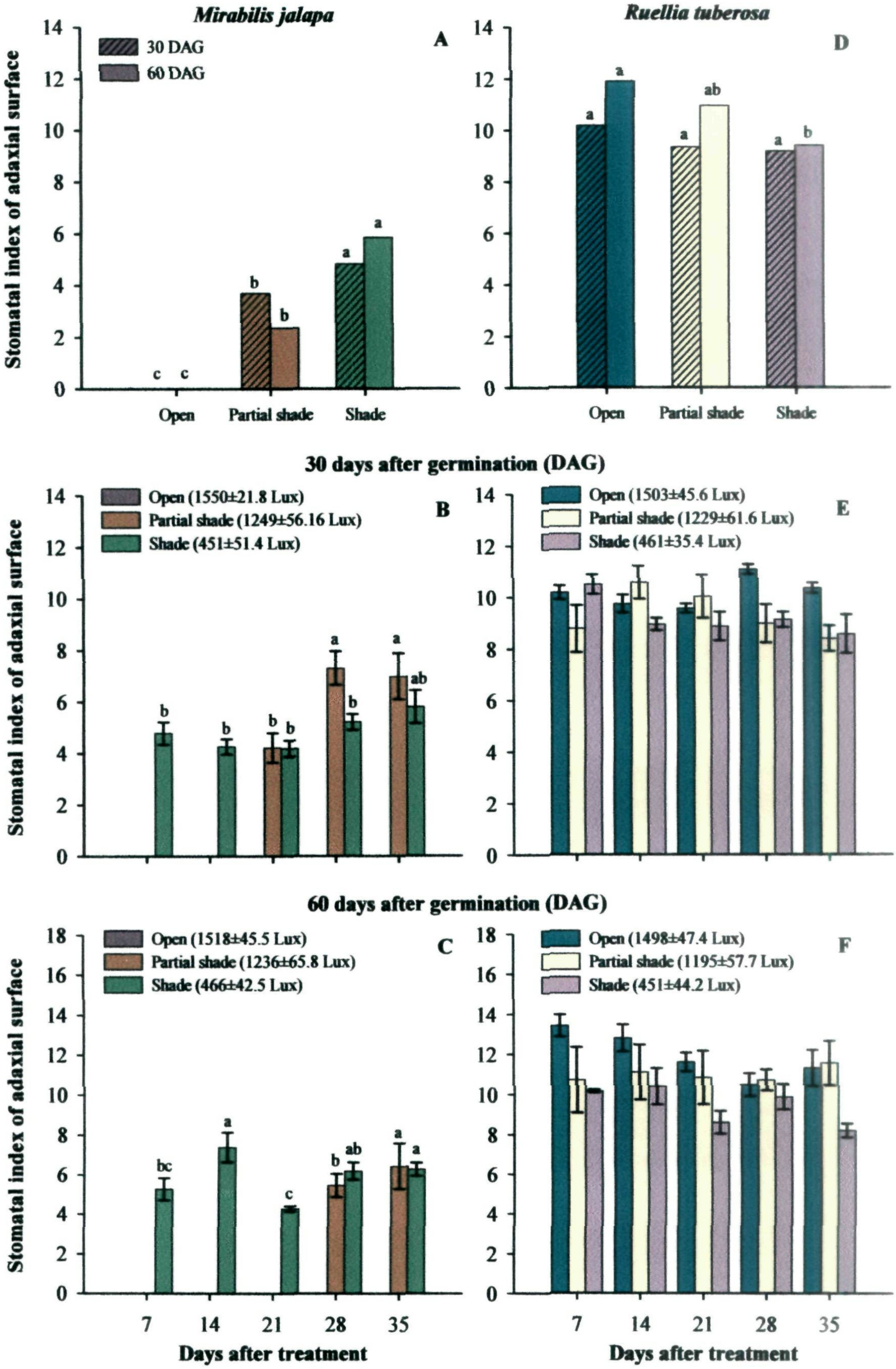


Figure 53. Effect of varying luminance on the stomatal index of adaxial surface of selected species (Mean ± SE) exposed at 30 days and 60 days (pre-flowering and post-flowering stages) for 5 weeks. Stomata were absent in open light in *Mirabilis jalapa* (B and C). Bars signified with common alphabets shows non-significant difference. (Data in annexed Table 54).

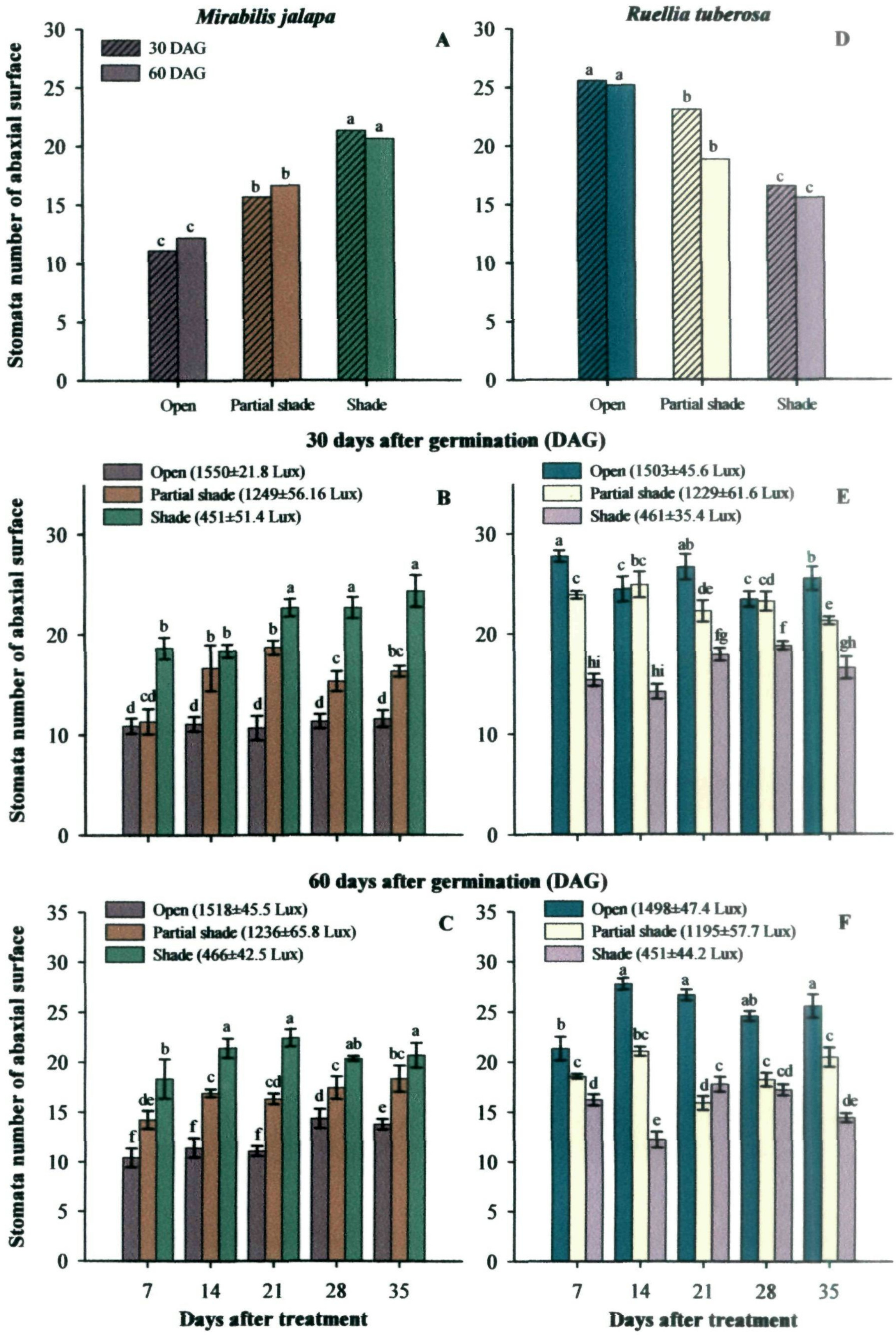


Figure 54. Effect of varying luminance on the stomata number of abaxial surface of selected species (Mean ± SE) exposed at 30 days and 60 days (pre-flowering and post-flowering stages) for 5 weeks. Bars signified with common alphabets shows non-significant difference. (Data in annexed Table 55).

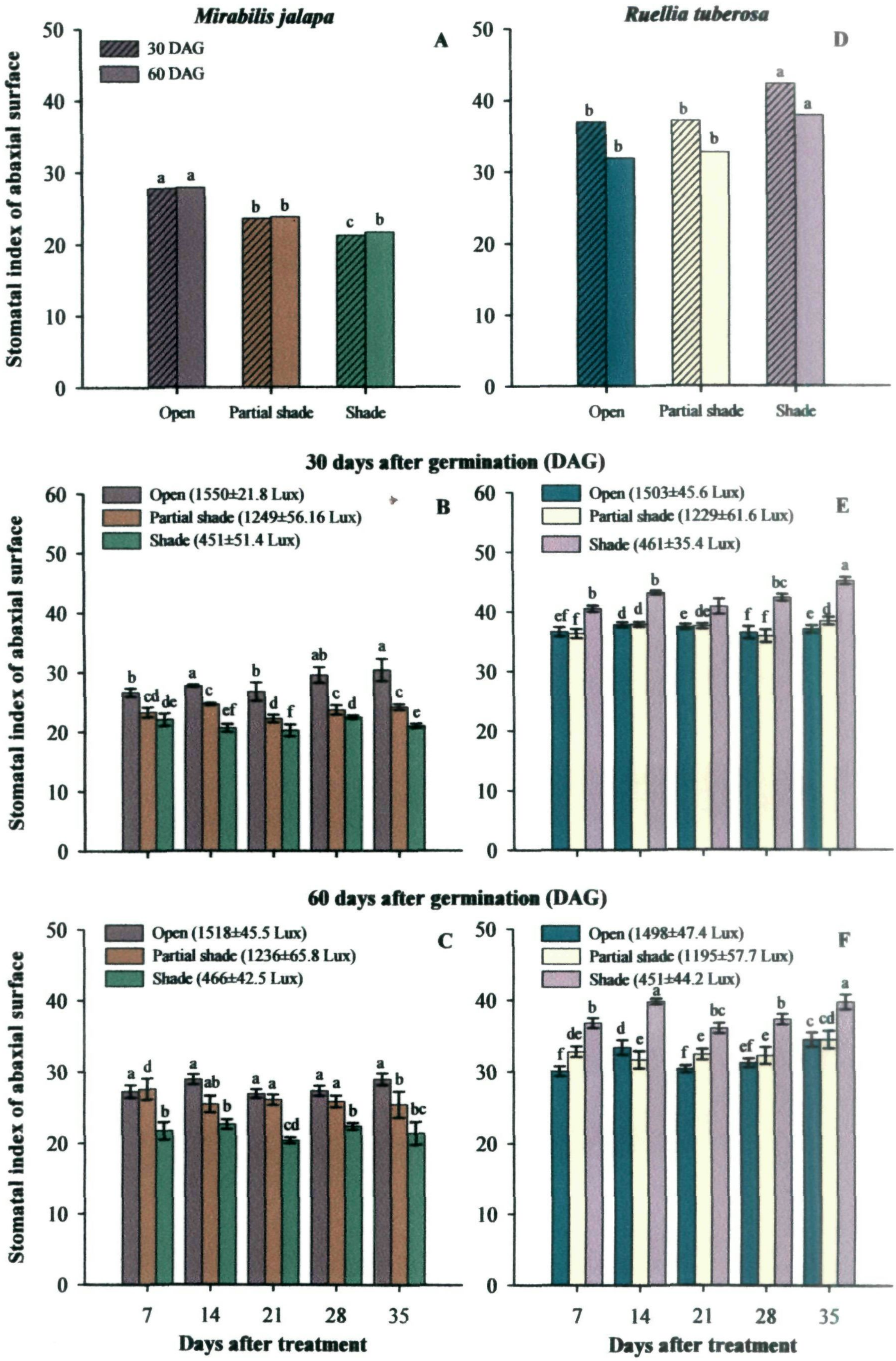


Figure 55. Effect of varying luminance on the stomatal index of abaxial surface of selected species (Mean ± SE) exposed at 30 days and 60 days (pre-flowering and post-flowering stages) for 5 weeks. Bars signified with common alphabets shows non-significant difference. (Data in annexed Table 56).

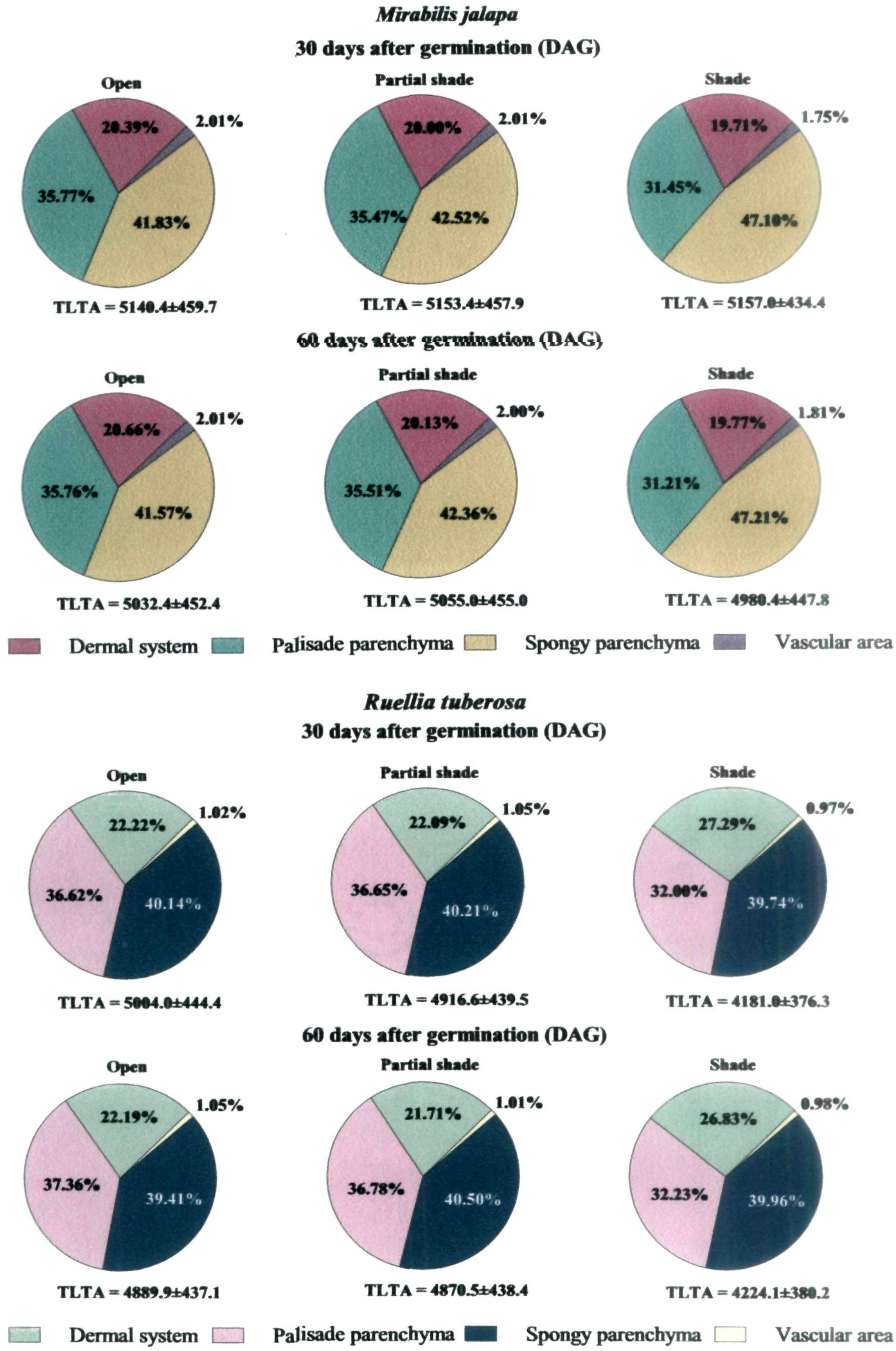


Figure 56. Relative proportion of leaf tissue systems of selected plants with respect to varying luminance exposed at 30 days and 60 days (pre-flowering and post-flowering stages). (Data in annexed Table 57).
Mean±SD, TLTA-Total leaf tissue area.

stages. The palisade and spongy parenchyma in both the plants had highest variation in response to light factor at both the stages. The palisade area in *Mirabilis jalapa* was higher in the leaves of plants kept under shade. In *Ruellia tuberosa*, the increase in dermal system appeared to be mainly at the cost of spongy parenchyma (Figure 56).

d) Reproductive growth

In *Mirabilis jalapa* and *Ruellia tuberosa*, the open and partial shade at post-flowering stages increased floral bud number. The shade at pre-flowering stage delayed bud formation in both the species (Figure 57). The floral bud emergence in *Mirabilis jalapa* was relatively higher in plants exposed to open light at pre-flowering stage (Figure 57B). In *Ruellia tuberosa*, the long term exposure to open and partial shade at both the stages did not affect floral bud number significantly (Figure 57E and F). The floral bud formation increased in *Mirabilis jalapa* exposed to partial light at post-flowering stage (Figure 57C). The plants of *Mirabilis jalapa* exposed to shade up to 14 days had few floral buds but further exposure to shade led to abortion of floral bud (Figure 57C). The plants of *Ruellia tuberosa* exposed to shade at post-flowering stage reduced the floral bud number within 7 days and increased their abortion thereafter.

The open and partial shade enhanced the flowering in *Mirabilis jalapa* and *Ruellia tuberosa* both. The effect was more prominent at post-flowering stage. Among the two selected species, flowering of *Mirabilis jalapa* was relatively more sensitive to light. The impact of open and partial shade in *Mirabilis jalapa* increased with the duration of exposure (Figure 58B). The exposure to shade for 14 days at post-flowering stage reduced the flowering significantly in *Mirabilis jalapa* but no significant effect on flowering was recorded on exposure for 21 to 35 days to open light and partial shade (Figure 58C). In *Ruellia tuberosa*, the plants kept under shade at pre-flowering stage did

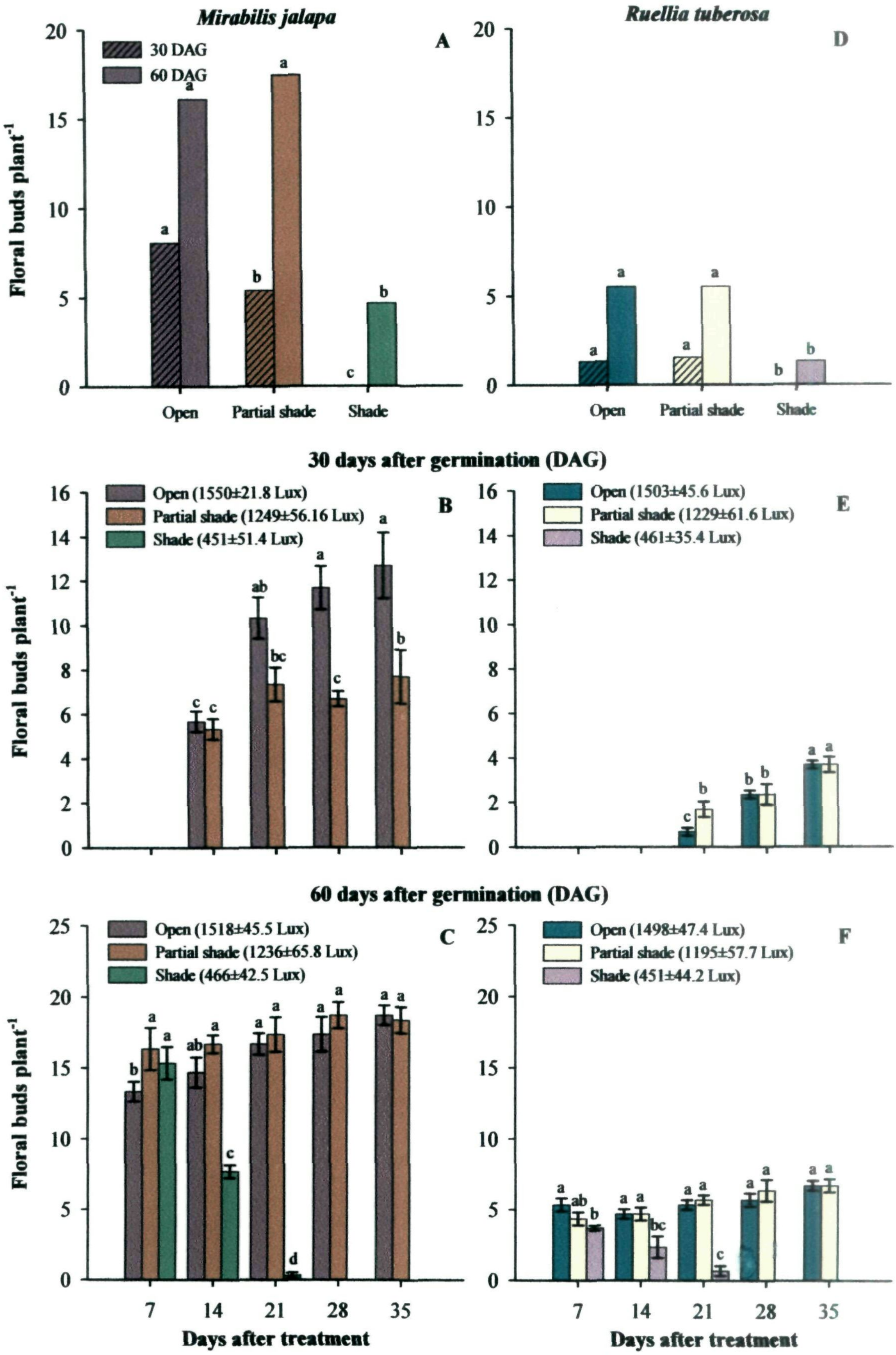


Figure 57. Effect of varying luminance on the floral buds plant^{-1} of selected species (Mean±SE) exposed at 30 days and 60 days (pre-flowering and post-flowering stages) for 5 weeks. No floral buds were recorded in the pots kept under shade (B and E). Bars signified with common alphabets shows non-significant difference. (Data in annexed Table 58).

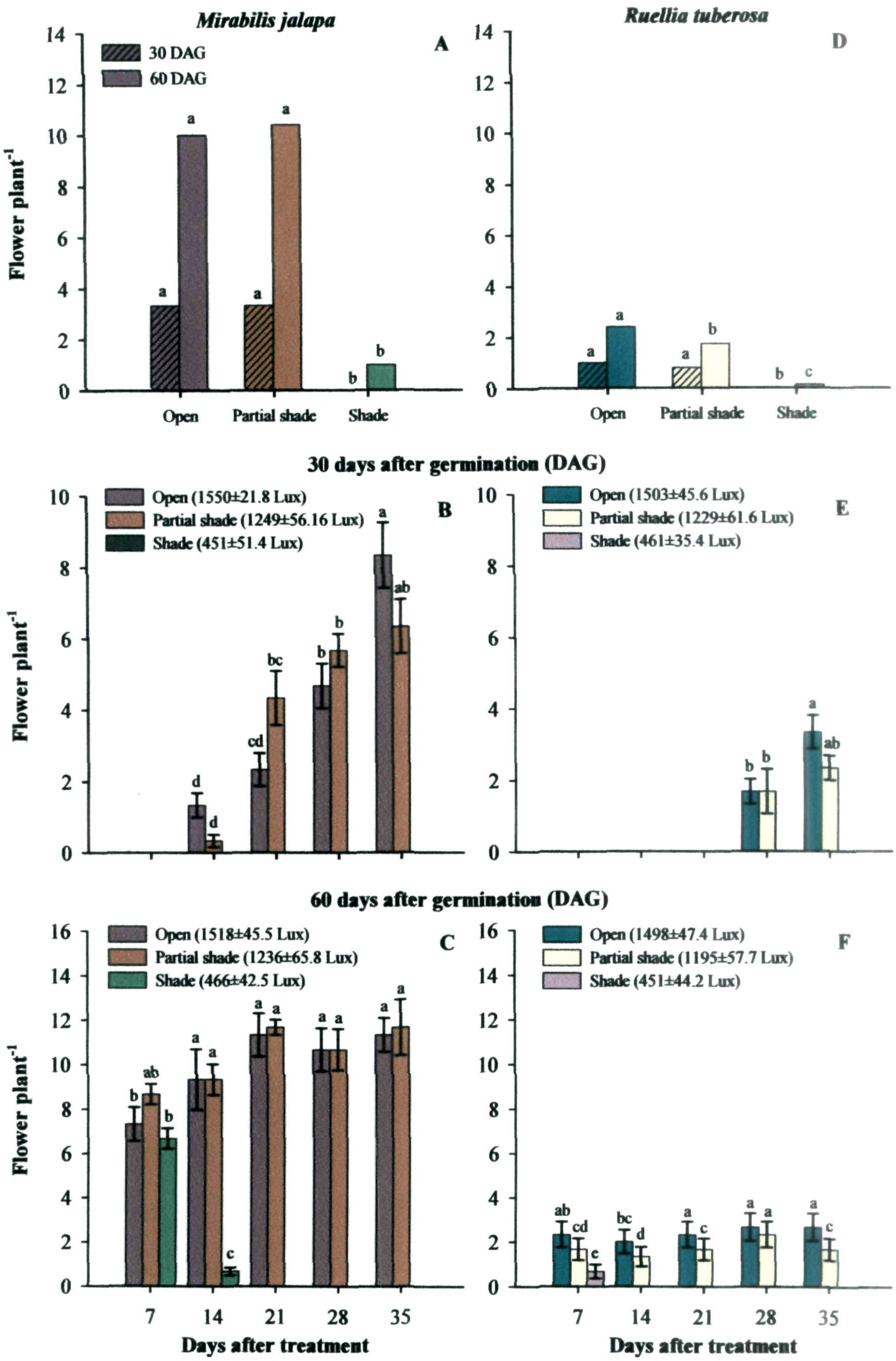


Figure 58. Effect of varying luminance on the flower plant^{-1} of selected species (Mean±SE) exposed at 30 days and 60 days (pre-flowering and post-flowering stages) for 5 weeks. No flowers were recorded in the pots kept under shade (B and E). Bars signified with common alphabets shows non-significant difference. (Data in annexed Table 59).

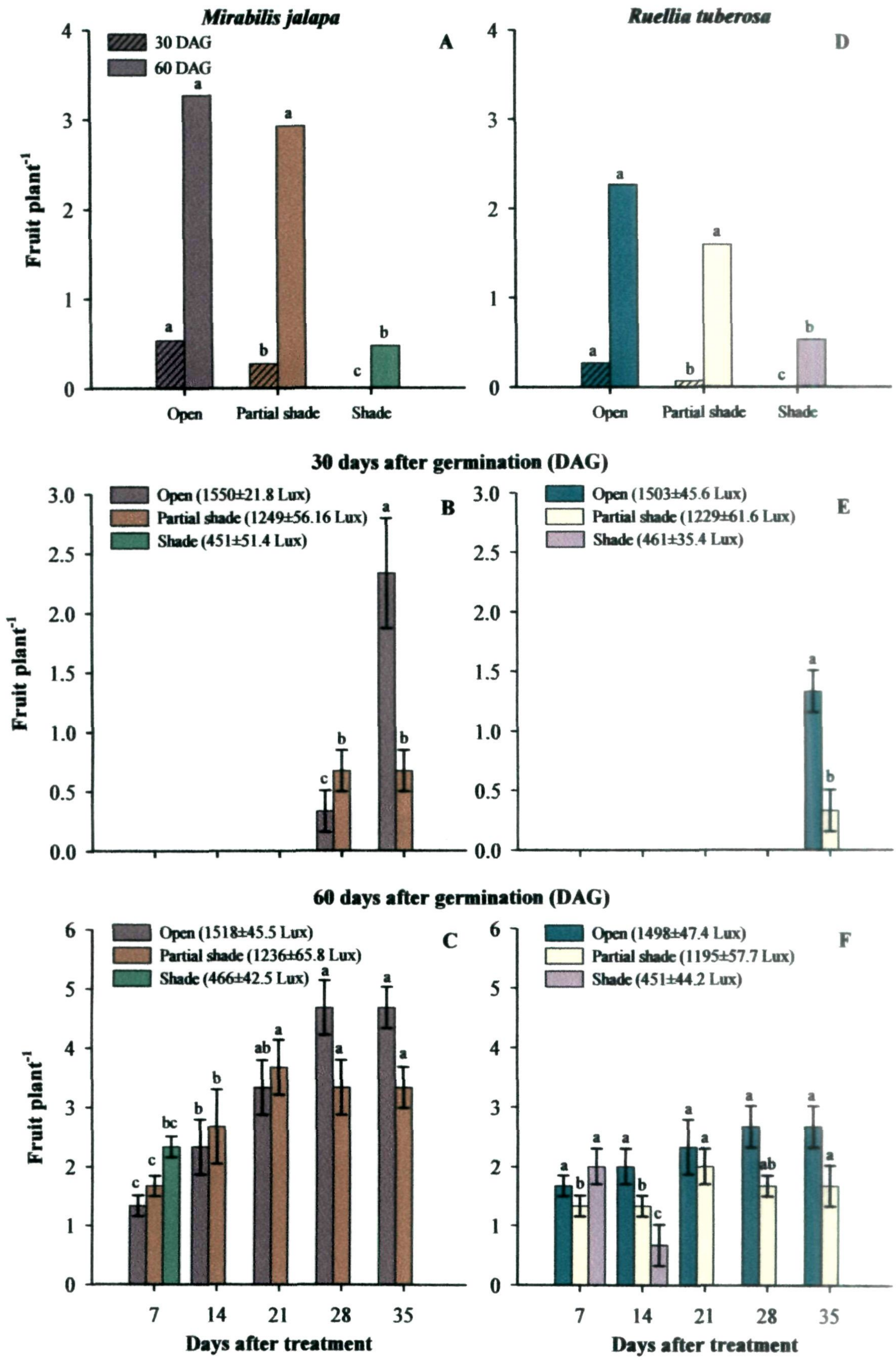


Figure 59. Effect of varying luminance on the fruit plant^{-1} of selected species (Mean±SE) exposed at 30 days and 60 days (pre-flowering and post-flowering stages) for 5 weeks. No fruits were recorded in the pots kept under shade (B and E). Bars signified with common alphabets shows non-significant difference. (Data in annexed Table 60).

not bear flowers. Exposure to open light or partial shade for 28 to 35 days at pre-flowering stage significantly increased flowering in *Ruellia tuberosa*. The flowering at post-flowering stage of *Ruellia tuberosa* did not significantly vary when kept in open light for 7 to 35 days (Figure 58F). But partial shade for 28 days increased flowering (Figure 58F). The plants of *Ruellia tuberosa* kept in shade for 7 days at post-flowering stage had flowers (Figure 58F).

The fruit setting was best in both the selected plants when kept under open light at pre- and post-flowering stages (Figure 59B, C, E and F). The partial shade up to 21days at post-flowering stage increased flowering in *Mirabilis jalapa* (Figure 58C). The fruit setting was significantly high under open light and partial shade in both the species (Figure 59A and D) particularly when exposed at post-flowering stage. The fruit setting in both the species was best, when plants were kept for 35 days in open light at pre-flowering stage (Figure 59B and E). The fruit setting in both the selected plants were significantly high under shade as recorded in first 7 days at post-flowering stage (Figure 59C and F). The partial shade at post-flowering stage increased fruit number up to 21 days of exposure and thereafter, there was no significant change in fruit number. So was the case of *Ruellia tuberosa* (Figure 59C and F). But long term (35 days) exposure to open light at pre- and post-flowering stages enhanced fruit setting in both the selected plants.

The seed output in both the species was highest under open light followed by partial shade (Figure 60A and D). Under shade, the seed setting was initially recorded in *Mirabilis jalapa* but the fruits aborted after 14 days of exposure (Figure 60B). In *Ruellia tuberosa*, the shade at initial stage reduced seed output but prolonged exposure to shade (21 days) led to complete abortion of fruits (Figure 60E). The impact of light variation on average seed output was significant in *Mirabilis jalapa*. In *Ruellia tuberosa*, the open

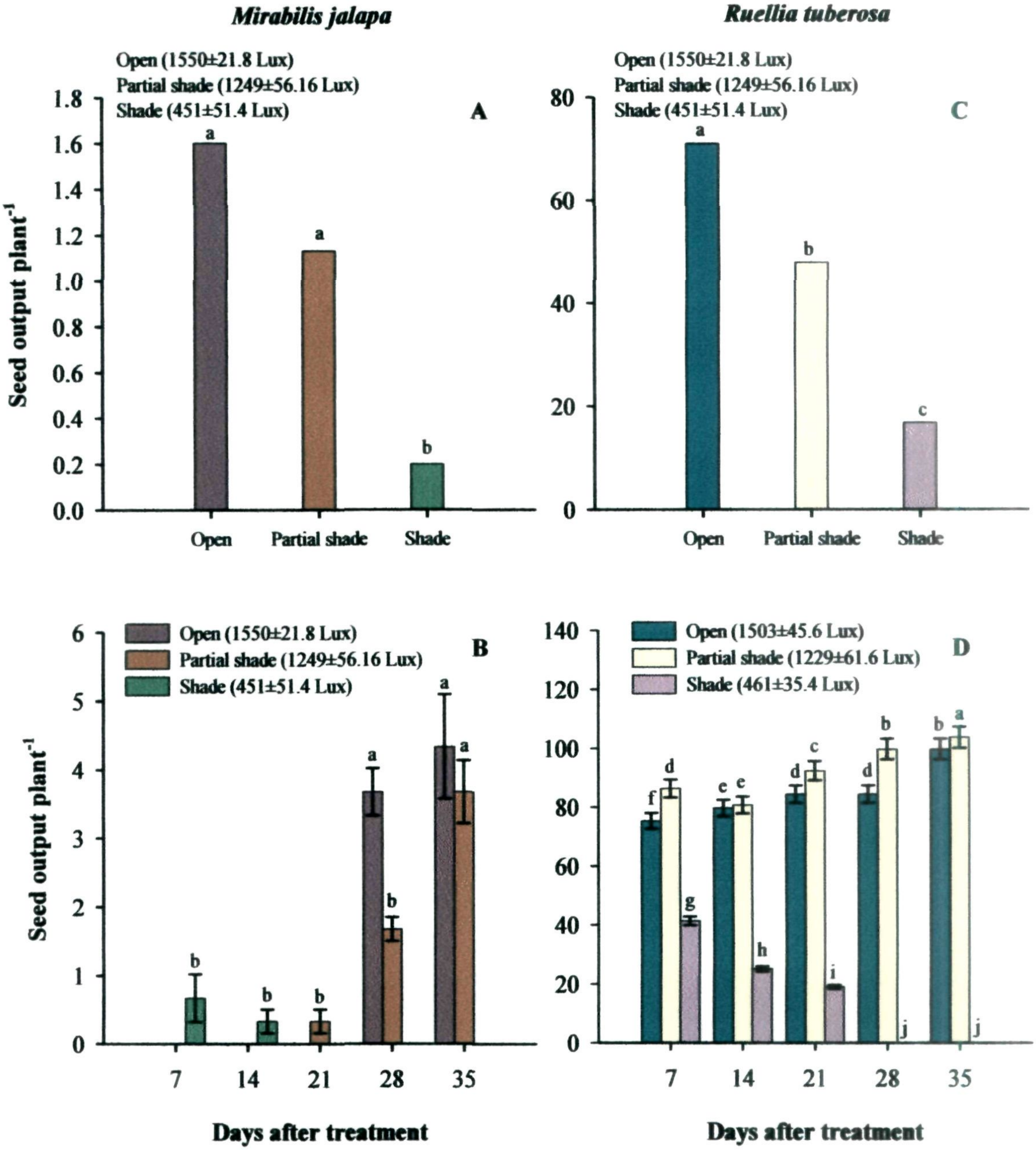


Figure 60. Effect of varying luminance on the seed output plant^{-1} of selected species (Mean±SE) exposed at 60 days (post-flowering stages) for 5 weeks. No seed setting were recorded at 30 days after germination stage. Bars signified with common alphabets shows non-significant difference. (Data in annexed Table 61).

and partial shade did not significantly affect average seed output from 7 to 35 days of exposure (Figure 60E and F).

Impact of root exudates on *Mirabilis jalapa*

The root exudates of *Argemone mexicana, Malvastrum coromandelianum* and *Parthenium hysterophorus* did not affect all selected physio-morphological parameters of *Mirabilis jalapa* (Table 1). The high dose of root exudates of all the three species had minute allelopathic impact on pooled mean of plant height at post-flowering stage (Annexed Table 62), leaf number at pre-flowering stage (Annexed Table 63), chlorophyll-b at post-flowering stage (Annexed Table 67), stomata number on abaxial surface at post-flowering (Annexed Table 70) and stomatal index in abaxial surface at both the growth stages (Annexed Table 71) in *Mirabilis jalapa*.

To workout the invasional meltdown caused by *Parthenium hysterophorus*, the impact of root exudates of *P. hysterophorus* on *Mirabilis jalapa* and *M. jalapa* on *P. hysterophorus* were studied. The detailed impact of root exudates of *P. hysterophorus* on the growth of *M. jalapa* has been described (Page 94 and 100). The root exudate of *P. hysterophorus* had no impact on the growth of *M. jalapa* but the root exudates of *M. jalapa* promoted the growth of *P. hysterophorus*. The growth promoting impact of the root exudate of *M. jalapa* on the growth of *P. hysterophorus* was proportionate to the concentration of the root exudate.

Impact of root exudates on *Ruellia tuberosa*

All concentrations of root exudates of selected component species (*Achyranthes aspera, Bidens pilosa, Capparis sepiaria, Malvastrum coromandelianum* and unidentified Acanthaceae) did not affect any growth parameters of *Ruellia tuberosa* at any stage of growth (Table 2). But the pooled mean of some parameters in response root

Plate 10

A, B and C – Visual effect of varying concentration of root exudates (100ml, 200ml and 400ml) of *Argemone mexicana* (A), *Malvastrum coromandelianum* (B) and *Parthenium hysterophorus* (C) on 60 days old *Mirabilis jalapa*.

Bars equal to 100mm.

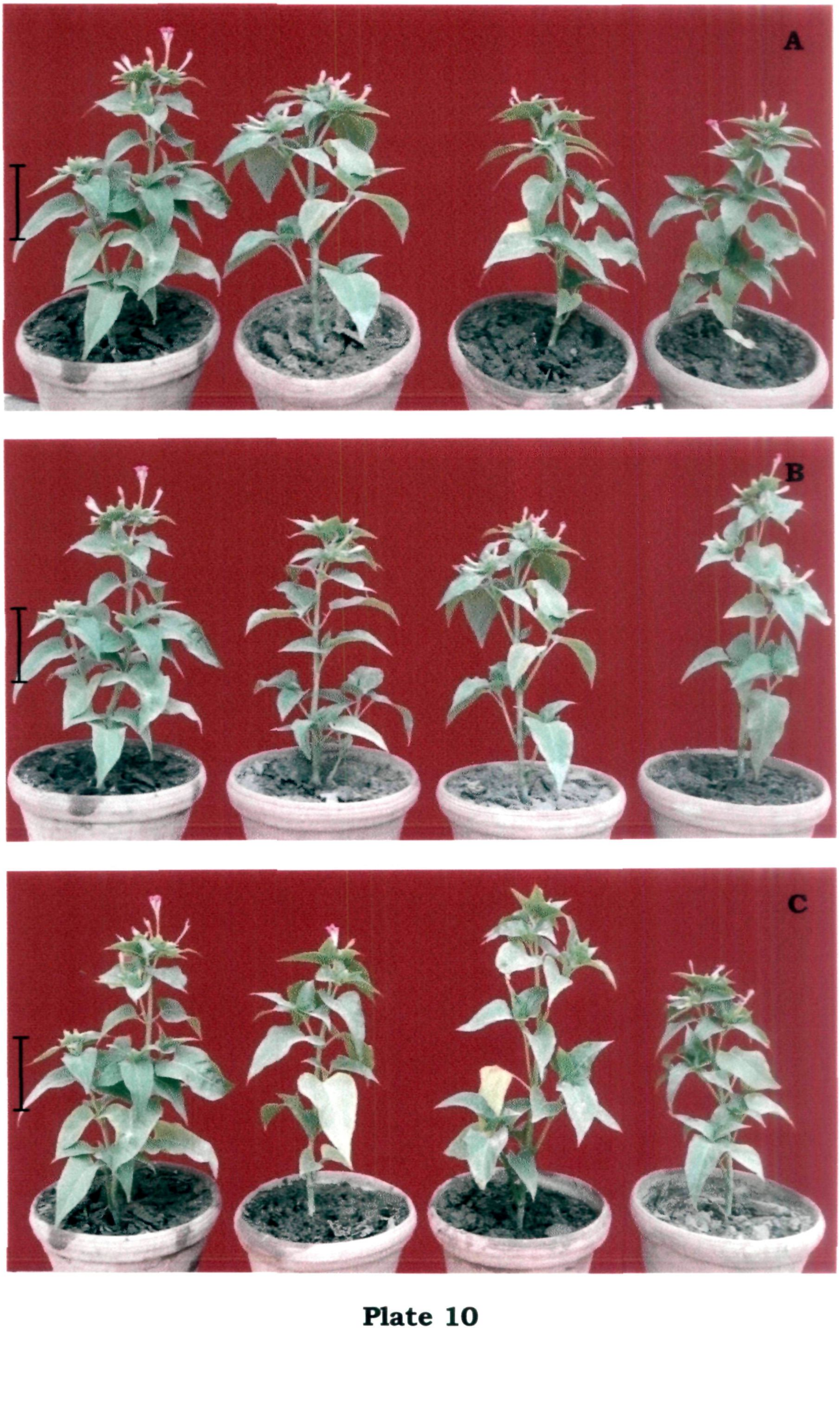


Plate 10

Table 1: Impact of varying amounts of root exudates of three selected component species on selected growth of *Mirabilis jalapa* treated at varying growth stages (30 and 60 days after germination) and studied up to 35 days (summary of tables 62 to 76).

S. No.	Selected growth parameters of *Mirabilis jalapa*	Root exudates of selected component species	Growth stages	Quantity of root exudates (ml)		
				100	200	400
1.	Stem (height, biomass), Leaf (number, area), Relative water content, Chlorophyll (a, b, total), Number (buds, flowers, fruits and seeds), Stomata number and index (abaxial surfaces), leaf tissue proportion	*Argemone mexicana*	30DAG	ns	ns	ns
			60DAG	ns	ns	ns
2.	Stem (height, biomass), Leaf (number, area), Relative water content, Chlorophyll(a, b, total), Number (buds, flowers, fruits and seeds), Stomata number and index (abaxial surfaces), leaf tissue proportion	*Malvastrum coromandelianum*	30DAG	ns	ns	ns
			60DAG	ns	ns	ns
3.	Stem (height, biomass), Leaf (number, area), Relative water content, Chlorophyll(a, b, total), Number (buds, flowers, fruits and seeds), Stomata number and index (abaxial surfaces), leaf tissue proportion	*Parthenium hysterophorus*	30DAG	ns	ns	ns
			60DAG	ns	ns	ns

DAG = days after germination; ns = non-significant; 100, 200 and 400 = root exudates of one, two and four plants, respectively

Plate 11

A – Visual effect of varying concentration of root exudate (100ml, 200ml and 400ml) of *Mirabilis jalapa* on *Parthenium hysterophorus* at 30 days after germination stage.

B – Effect of varying concentrations of root exudates of *Mirabilis jalapa* (100, 200, 400 ml) on plant height, leaf $plant^{-1}$, internodes $plant^{-1}$ and inflorescence $plant^{-1}$ of *Parthenium hysterophorus* treated at 30 days stage.

Bars equal to 100mm.


A

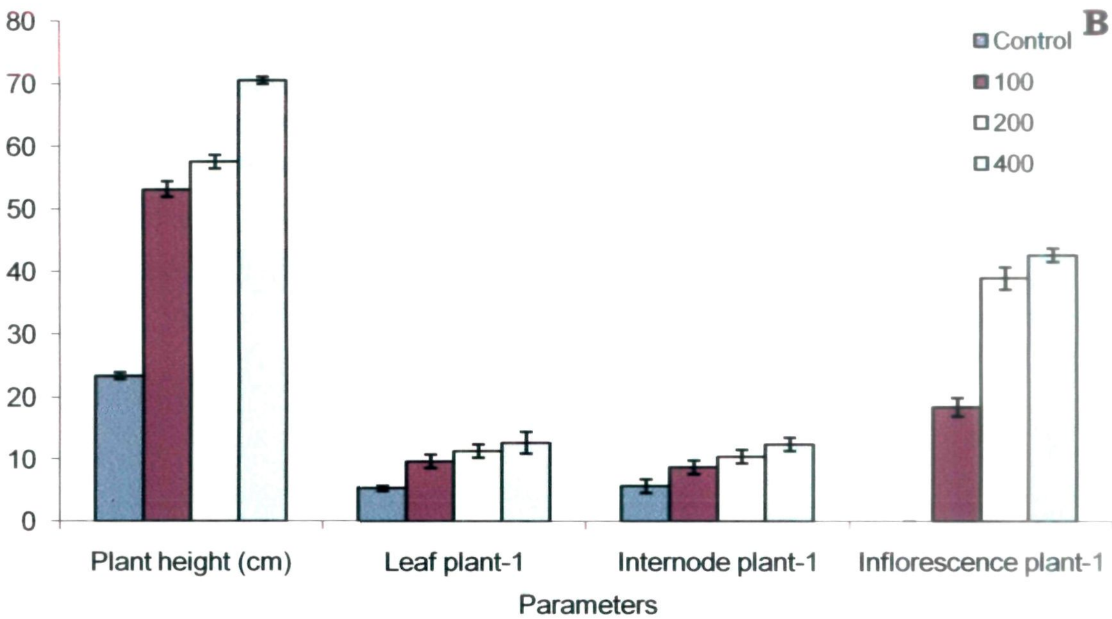

B
Control
100
200
400
80
70
60
50
40
30
20
10
0
Plant height (cm)
Leaf plant-1
Internode plant-1
Inflorescence plant-1
Parameters

Plate 11

exudates of some component species varied significantly viz., plant height (Annexed Table 77), leaf number (Annexed Table 78), chlorophyll-a (Annexed Table 81) at pre- and post-flowering stage and chlorophyll-b at pre-flowering stage (Annexed Table 82).

Plate 12

A, B, C, D and E – Visual effect of varying concentration of root exudates (100ml, 200ml and 400ml) of *Achyranthes aspera* (A), *Bidens pilosa* (B), *Capparis sepiaria* (C), *Malvastrum coromandelianum* (D) and Unidentified Acanthaceae (E) on the growth of 60 days old *Ruellia tuberosa*.

Bars equal to 100mm.

Plate 12

Table 2: Impact of varying amounts of root exudates of three selected component species on selected growth of *Ruellia tuberosa* treated at varying growth stages (30 and 60 days after germination) and studied up to 35 days (summary of tables 77 to 93).

S. No.	Selected growth parameters of *Ruellia tuberosa*	Root exudates of selected component species	Growth stages	Quantity of root exudates (ml)		
				100	200	400
1.	Stem (height, biomass), Leaf (number, area), Relative water content, Chlorophyll(a, b, total), Number (buds, flowers, fruits and seeds), Stomata number and index (adaxial, abaxial surfaces), leaf tissue proportion	*Achyranthes aspera*	30DAG	ns	ns	ns
			60DAG	ns	ns	ns
2.	Stem (height, biomass), Leaf (number, area), Relative water content, Chlorophyll(a, b, total), Number (buds, flowers, fruits and seeds), Stomata number and index (adaxial, abaxial surfaces), leaf tissue proportion	*Bidens pilosa*	30DAG	ns	ns	ns
			60DAG	ns	ns	ns
3.	Stem (height, biomass), Leaf (number, area), Relative water content, Chlorophyll(a, b, total), Number (buds, flowers, fruits and seeds), Stomata number and index (adaxial, abaxial surfaces), leaf tissue proportion	*Capparis sepiaria*	30DAG	ns	ns	ns
			60DAG	ns	ns	ns
4.	Stem (height, biomass), Leaf (number, area), Relative water content, Chlorophyll(a, b, total), Number (buds, flowers, fruits and seeds), Stomata number and index (adaxial, abaxial surfaces), leaf tissue proportion	*Malvastrum coromandelianum*	30DAG	ns	ns	ns
			60DAG	ns	ns	ns

5.	Stem (height, biomass), Leaf (number, area), Relative water content, Chlorophyll(a, b, total), Number (buds, flowers, fruits and seeds), Stomata number and index (adaxial, abaxial surfaces), leaf tissue proportion	Unidentified Acanthaceae	30DAG	ns	ns	ns
			60DAG	ns	ns	ns

DAG = days after germination; ns = non-significant; 100, 200 and 400 = root exudates of one, two and four plants, respectively

Discussion

DISCUSSION

The present studies were carried out on *Mirabilis jalapa* and *Ruellia tuberosa*. Both these species were reported as garden escapes (Smith 1981, Meyer and Lavergne 2004, Reddy 2008) and invaded mostly in the areas of high human activity (Staples *et al.* 2000). During the survey for present study, both these species were found growing in an area relatively undisturbed (minimum human interference) but in a close vicinity of the university campus (Aligarh Muslim University) with high human interferences.

Milbau *et al.* (2009) classified invasibility of species considering six spatial scales (at micro to continental level), eight abiotic factors (climate, topography, land covers, land use, soil type, disturbance, resources and microclimate), five biotic factors (mutualism, competition, facilitation, herbivory and pathogens), stage of invasion process and measures of species success (germination, biomass, richness, invasible capacity, presence, abundance and per cent cover) etc. In the present study, the selected species have been studied at the local spatial scale (1-10km) and site level (10-1000m). The climate of Aligarh (India) and that of the native place of the selected invasive species is a typical tropical climate. Taking into the account the factors affecting invasibility (Milbau *et al.* 2009), the present findings are in agreement with the factors classified at micro-climate, site level and local level in addition to the similarity of tropical climate at continental level as described by Milbau *et al.* (2009).

In the present study, the field selected was relatively a vast open field left unused for about 10 years. Several wild plants including native and some invasive species have occupied the area. In the selected field *Mirabilis jalapa* and *Ruellia tuberosa* were found growing along with other species as described earlier (Page 65-67). Both these species are known to be invasive (Meyer and Lavergne 2004, Reddy 2008). The site is surrounded by two halls of residence from eastern side, railway track from western side and Radio Colony from northern side as well as Faculty of Agriculture Buildings on one side (Map, Page 33). The selected area was free from human activities but surrounded by the establishment of high human activities. The invasion of both the selected plants (*Mirabilis jalapa* and *Ruellia tuberosa*) appears to be more likely as garden escapes from a nearby field. During the site selection the probability of major site difference was minimized by selecting 4 patches of vegetation in a single field following McIntosh *et al.* (1995), Ehrenfeld *et al.* (2001), Scott *et al.* (2001) and Hook *et al.* (2004). All 4 selected patches were named as Site1, Site 2, Site 3 and Site 4. The location of selected field as described above is vulnerable to plant invasions as most of the invasible sites are described to be located around the establishments of high human activity (Staples *et al.* 2000). The soil disturbance on the other hand alters the resources availability and creates suitable conditions for plant invasion (D'Antonio 1993, Thompson *et al.* 2001, Jia *et al.* 2009). It is reported that during disturbance regimes, large scale destructions of native species increases the availability of soil nutrient and space and also reduce soil competition for invader species (Burke and Grime 1996, Levine and D'Antonio 1999, Stohlgren *et al.* 2001, Thompson *et al.* 2001). But in the present study, only a central part of the field (Map, Page 33) was under human activity (construction of new building for Faculty of Agriculture).

All 4 selected sites had marginal variations in nutrient status, soil moisture and luminance (Figure 1 and 2). Due to establishment of variable number of native species in variable time, patchiness was created. The small community patches consisted of variable number of species. The difference in the growth and life cycles of component species in each stand may have caused variation in the soil nutrient status. The selected field was initially under cultivation and nutrient status may have been more or less uniform besides uniform spacing, fertilizer and water applications. The settlements of wild species at variable times and places may have caused heterogeneity in soil properties due to variations in nutrient uptake and their binding into biomes. Plant invasions in many ecosystems have been found to induce heterogeneity in the soil properties (Hobbie 1992, Van-Breemen and Finzi 1998, Ehrenfeld 2003, Ehrenfeld and Scott 2001, Vanderhoeven *et al.* 2006). The selected invasive species may have dried advantage of nutrient heterogeneity. Some invasive species can form monospecific stands in sites with different resident vegetation and soil nutrients which may result into patchiness of vegetation. The invasive species cause imbalance in the functioning of natural and agriculture ecosystem (Parker *et al.* 1999).

Variations in Community

As evident from result of the community studies (Figure 4–6), the total number of native species at non-invaded Site 4 were 25. Site 1 invaded by *Mirabilis jalapa*, had only 14 native species. At Site 2 and 3, invaded by *Ruellia tuberosa*, the species number reduced to 7 and 18 respectively. All the 4 selected sites were located in one field and most of the native species there in had wide ecological amplitude. Therefore, the native species were not likely to be eliminated by minor micro-climatic variations. It is not evident whether the selected invasive species have occupied the vacant niches of their respective sites or the invasive species had some invasive advantage and eliminated some of the native species after their establishments at respective sites. Lambdon *et al.* (2007) noted three main characteristics of invading species causing them to establish and flourish in an existing ecosystem viz., by occupying the niche of one or more native species and ultimately out compete them (Schnitzler and Muller 1998, Callaway and Aschehoug 2000, Chittka and Schürkens 2001) or by coexisting with native species, each species possessing an advantage across a different part of the initial niche space (Dietz and Ullmann 1997, Cizek *et al.* 2003) or by filling unoccupied niches (Vitousek 1988). In Europe, *Solidago gigantea* occupied a broader niche and formed a monospecific stand (Weber and Jakobs 2005, Vanderhoeven *et al.* 2006).

In the present study, Site 1 invaded by *Mirabilis jalapa* had 10 species lesser than non-invaded Site 4, while Site 2 and 3 invaded by *Ruellia tuberosa* had 7 and 18 species (respectively) lesser than non-invaded Site 4 (Figure 4, 5, 6 and 7). Sites 2 and 3 differed mainly in soil moisture (Figure 1). From the community structure, it can not be established if the invasion of plants cased variation in the soil or variation in soil moisture led to invasion. The *Capparis sepiaria* present at Site 3 is a xerophytic plant (Mishra *et al.* 2007). The presence of *Capparis sepiaria* at Site 2 indicates that site was drought stressed. The decrease in stomata number in *Ruellia tuberosa* at Site 2 as compared to adequately irrigated plants in pots (Figure 27) indicates that adequate moisture in pots increased stomata number. But drought (Figure 38) did not affect stomata number and index significantly. These results suggested that *Ruellia tuberosa* is well adapted to drought and occupied the niche of drought sensitive species.

The second possibility of the loss of plant diversity at invaded site is of direct competition of invaders with natives. In such cases, the diversity reduction occurs due to direct competition of invasive plants with the natives. The community attributes (Figure 8 and 9) indicate that the invasion of both the species have reduced the community richness and species diversity. The invasive plants are known to exert significant impacts on the diversity of the native communities (Vitousek 1990, Frankel 1999, Mack *et al.* 2000, Woitke and Dietz 2002, Levine *et al.* 2003). The cause of variation in community attributes may be due to direct interference in the niches of native plants (Lambdon *et al.* 2007) or indirect through variable life cycles of the existing component species resulting into uptake and locking of nutrients and thereby reducing the availability of nutrients for larger number of native species.

At invaded site of *Mirabilis jalapa* (Site 1), *Parthenium hysterophorus* was found growing as another co-dominant invasive species. The *Parthenium hysterophorus* was accidently introduced in India during 1960's and possess allelopathic and high reproductive capacity as invasive traits (Pandey and Dubey 1989). The *Parthenium* species inhibits germination and growth of several native species (Adkins and Sowerby 1996, Sharma *et al.* 2005). The root exudates studies established that *Mirabilis jalapa* promoted the growth of *Parthenium* sp. (Plate 12). The growth performance (stem height, leaf number and area) of *Mirabilis jalapa* at Site 1 was better than in pots (Figure 11). The positive impact of root exudates of *Mirabilis jalapa* on the growth of *Parthenium* and in turn no impact of the root exudates of *Parthenium* on the growth of *M. jalapa* appears to be an invasive strategy of *M. jalapa*. The strategy of promoting growth of *Parthenium* may be an invasional meltdown process. The invasion success strategies (Inderjit *et al.* 2005) include invasional meltdown (Simberloff and Van Holle 1999, Simberloff 2006), biotic resistance (Maron and Vilà 2001), resource fluctuation (Davis *et al.* 2000, Grime 2002), superior competitor (Bakker and Wilson 2001, Vilà and Weiner 2004), enemy of my enemy is my friend (Hay *et al.* 2004), enemy inversion (Pearson and Ortega 2001), besides many other factors.

At non-invaded Site 4, the *Parthenium* was not a part of the 25 component species. The community of 18 species at Site 3 includes *Bidens pilosa* and *Ageratum conyzoids* along with *Ruellia tuberosa* (Figure 6). The former two species (*B. pilosa* and *A. conyzoids*) are reported to be invasive species (Liu *et al.* 2006). The community at Site 2 (invaded by *Ruellia tuberosa*) consisted of 7 species. The significant reduction in the species diversity at Site 2 may have been influenced by variations in soil factors in addition to invasion of *Ruellia tuberosa*. It is likely that moisture deficiency may have made the site invasive for *Ruellia tuberosa* due to inability of many native species to grow at Site 2. Thus, the vacant niches were occupied by *R. tuberosa*. This indicates that *R. tuberosa* had adaptability to water stress as an invasive trait.

The community indices show that Site 4 was heterogeneous with high community richness while Site 1 and 2 invaded by *Mirabilis jalapa* and *Ruellia tuberosa*, respectively were relativity homogenous. At invaded sites, the diversity index reduced significantly (Figure 8). In earlier studies, some non-native species viz., *Parthenium hysterophorus*, *Ageratum conyzoids* and *Lantana camara* have been found to reduce the species diversity, IVI and richness (Kohli *et al.* 2004). The invasion of both the selected species had similar impact on the invaded community.

From the soil analysis, it is also evident that the moisture content at Site 2 was low. At this site *Capparis sepiaria* (a xerophytic species) grows along with *Ruellia tuberosa*. The *Ruellia tuberosa* having advantage to thrive under low moisture may have invaded along with some xerophytic species as competition for water, nutrition and space reduced. Similar causes of invasion have been reported earlier (Almasi 2000, Case and Crawley 2000, Shea and Chesson 2002). The *Ruellia tuberosa* at Site 3 had 18 component species. At this site the moisture was adequate (Figure 1). This indicates that *Ruellia tuberosa* is having wider ecological amplitude for soil moisture. The invasive plants are known to have wider ecological amplitudes (Anonymous 2005). Moreover, Sites 2 and 3 were receiving relatively lesser light due to partial shade of sparse tree canopies during various part of the day. The experiment conducted in the present study, on the impact of varying light regimes, moisture contents and root exudates established that water stress and shade affected the growth of *Ruellia tuberosa* adversely. Unlike *Mirabilis jalapa*, the growth of *Ruellia tuberosa* reduced under shade and water stress conditions in the field as compared to cultivated individuals (kept in open with adequate moisture). The sclerophyll shrubland in Australia was seldom colonized by invasive species except in area where well drained, nutrient poor soils were modified by the additional organic matter and nutrients from urban run-off (Lake and Leishman 2004). In the present study, the sites are rich in nutrients and organic matters. Thus the invasive species in the selected well drained field feasibly had welcomed opportunity. In New Zealand, few introduced species established in the shaded understory of the forest system that dominated the land prior to the arrival to humans (McGlone 1989, Jesson *et al.* 2000, Lloyed *et al.* 2006). It is thus, evident that the selected sites had susceptibility to invasion.

The relative density of *Ruellia tuberosa* at Site 2 was marginally lower than at Site 3. Whereas, the total number of component species at Site 2 and Site 3 were 7 and 18, respectively. At non-invaded Site 4, the total species were 25. This indicates that *Ruellia tuberosa* had its own fundamental niche irrespective of the 7 species at Site 2 and 18 species at Site 3. The availability of the fundamental niche at both the sites led to the invasion of *Ruellia tuberosa* at Sites 2 and 3. It is less likely that *Ruellia tuberosa* after its invasion out competed with the native species and reduced their number from 25 to 7 at Site 2 and 18 at Site 3 (Figure 5 and 6). Possibly most of the native species may have been eliminated due to low soil moisture availability, while a few native species may have been out competed. The invasive plants are known to out compete with the native plants (Vitousek *et al.* 1996, Wilcove *et al.* 1998, Parker *et al.* 1999, Mack *et al.* 2000, Cronk and Fuller 2001, Levine *et al.* 2003). Ewe and Stemberg (2003) noted that invasions of *Schinus terebenthifolius* displaced and reduced diversity of native species as was also noted in case of invasions of *Agave* (Badano and Pugnaire 2004), *Melinus minutifolia* (Hoffmann *et al.* 2004, El-Keblawy and Al-Rawai 2007). At Site 3, the relative density of species co-occurring with *Ruellia tuberosa* was far lower than those co-occurring at Site 2. One unidentified Acanthaceae member occurred with similar density at both the Sites 2 and 3 invaded by *Ruellia tuberosa.* The relative dominance of *Ruellia tuberosa* at Site 3 was relatively lesser than at Site 2 (Figure 5D and 6D). This indicates that only dominance of *R. tuberosa* was influenced by larger number of native species at Site 3.

It may be noted that soil moisture at Site 2 was lesser than at Site 3 and 4 (Figure 1B). This indicates that invasion of alien species and elimination of native species depended on invasibility of site and low soil moisture. The *Ruellia tuberosa* at Site 2 had to compete with limited number of moisture tolerant species. The survival with equally good relative density at Site 2 having low soil moisture than at Site 3 indicate that *Ruellia tuberosa* had a broader ecological amplitude for moisture as an invasive trait. Under low moisture, *Ruellia tuberosa* survived by marginally reducing relative dominance only. The invasion of *Ruellia tuberosa* may have easily displaced certain species facing moisture stress at Site 2. The displacement of native species by *Agave* (a xerophytic species) is believed to have been caused due to increased invasibility of ecosystem under moisture stress as reported earlier (Badano and Pugnaire 2004). The richness index at Site 2 was lower as compared to Site 1 (invaded by *Mirabilis jalapa*) and Site 3 (invaded by *Ruellia tuberosa*). The species richness followed the trend of moisture availability at Sites 1-3. The low moisture made the ecosystem more invasive for *Ruellia tuberosa.* Adequate moisture at Site 3 and Site 1 as well as reduced light at Site 3 enhanced the richness index (Figure 1 and 8). In contrary, Duggin and Gentle (1998) and Milbau and Nijs (2004) noted that invasion success was promoted by light availability. The invasion success may be light dependent in the ecosystem where the native species are well adapted over the decades. The selected sites are located in a decade old deserted agriculture field, where the native species were also in a state of establishing themselves. Therefore, the impact of invasive species on species richness was more prominent in the present study even under minor moisture variations. The invasion of *Ruellia tuberosa* at Site 2 (with low soil moisture) and at Site 3 (with high soil moisture) indicates that the species has wider ecological amplitude for water requirements and thus invaded at drier parts of the field (Site 2). Wide ecological amplitude is a probable trait favoring invasiveness in terrestrial plants (Goldberg 1990, Piank 1994, Cronk and Fuller 1995, Sher and Hyatt 1999, Barrilleaux and Grace 2000, Anonymous 2005). The dry habitat at Site 2 is also evident from the presence of a xerophytic species *Capparis sepiaria* (Mishra *et al.* 2007). The richness and diversity indices in winter season increased at non-invaded Site 4 and reduced at Site 3 (Figure 9D). The increase in species richness in winter (high humidity) and monsoon (high soil moisture) season (Figure 1B and 3) is due to germination and growth of some native seasonal species (Figure 9A).

Autecological Studies

The impact of invasive species on ecosystem can best be measured at individual levels besides some attributes at community and genetic levels (Parker *et al.* 1999). The autecological studies are useful in understanding the invasive traits of the species and phenotypic plasticity in response to environmental variables faced in variable habitats. The plants have two major strategies of growth and survivorship namely k- and r-selection. The autecological studies conducted on both the selected plants include, the growth behaviour (plant growth, biological clock and survivorship in invaded community) and phenotypic variations (morpho-physio-histological variations) under varying microclimatic factors.

1) Growth behaviour

a) Plant growth

The growth of *Mirabilis jalapa* at Site 1 increased exponentially until July (Figure 10A), the plant height of *M. jalapa* was directly related with number of watering days or soil moisture as recorded in pot studies (Figure 28A and B). The root exudates of *Argemone mexicana*, *Malvastrum coromandelianum* and *Parthenium hysterophorus* did not adversely effect on any growth parameter (plant height, leaf number, chlorophyll content, stem biomass, stomata and total leaf tissue area) of *M. jalapa* (Table 1). The soil moisture thus, appears to be the main factor which limited the growth of *M. jalapa* in the field. The excessive growth of *M. jalapa* in the field as compared to cultivated ones indicates that *M. jalapa* had advantage over the component native species in exploiting minerals and soil moisture. This advantage of *M. jalapa* under field condition is a strong invasive trait. The main reason of its adaptability could be the tuberous storage roots (Leal *et al.* 2001). The tuberous storage roots may have helped *Mirabilis jalapa* to explore an unoccupied niche, conserve water and nutrients.

The chlorophyll and relative water content in the leaf tissues of *Mirabilis jalapa* were sensitive to varying soil moisture regimes (Figure 31, 32, 33 and 34). Similar results on sorghum genotypes have been reported earlier (Al-Hamdani and Barger 2003). The site of *M. jalapa* is a well drained but low lying along railway track and frequently receives water from adjacent areas. Thus, the moisture at Site 1 occasionally increased (Figure 1B). The individuals at Site 1 developed stomata on the upper surface (Figure 12). The stomata number increased in *M. jalapa* grown under shade (Figure 52B and C). This indicate that the stomata number in *M. jalapa* was determined by shade and moisture regimes. This phenotypic plasticity is an important invasive trait of species

(Daehler 2003, Rejmánek *et al.* 2005, Pyšek and Richardson 2007, Hulme 2008).

As compared to pot (maintained with adequate moisture and light), the vegetative growth of *Mirabilis jalapa* in field was higher from March to October. The higher vegetative growth during this period corresponded with higher stomata number feasibly for higher CO_2 intake. The higher biomass of the field individuals of *M. jalapa* (Figure 26) is in conformity of higher CO_2 intake and fixation. The plasticity of stomata number appears to be related with CO_2 intake rather than increase in transpiration with soil moisture. The stomata number in pot was sensitive to luminance variation. The stomata number on both the surfaces of leaf of *M. jalapa* increased in potted individuals exposed shade or even to partial shade at pre- or post-flowering stages (Figure 52). But the biomass in these individual decreased (Figure 51). This further indicates that open light and high moisture in field increased stomata number for higher CO_2 intake and energy fixation by *Mirabilis jalapa.*

In *Mirabilis jalapa*, the stomata developed on the adaxial surface of leaf in field individuals during January to June. During these months *M. jalapa* grows with *Parthenium hysterophorus* as one of the component species at Site 1. *Parthenium* is known to be a strong invader in all most all terrestrial ecosystems (Kohli and Rani 1994, Angiras and Saini 1997, Mukhopadhyay 1997) and inhibit the growth of other component species. The stomata number in *M. jalapa* did not change when treated with the root exudates of *Parthenium* (Table 1). But the root exudates of *Mirabilis jalapa* enhanced growth of *Parthenium* (Plate 12). This indicates a symbiotic relationship between 2 exotic species besides having separate fundamental niches of their own (as discussed earlier). At the time of germination at Site 1, large number of seedlings of *Mirabilis jalapa* thrived under the canopy of *Parthenium* (Figure 4A, B and C) as evident from the important value index (IVI) of *Mirabilis* and *Parthenium* between

January and June (Figure 4E) at Site 1.

The stomata appeared on adaxial surface of *Mirabilis jalapa* in the leaf of 1st flush at younger stage (January to June) while the leaves of 2nd flush (July to December) in older plants, did not have stomata on adaxial surface (Figure 12). This trait appears to be a phenotypic plasticity of *M. jalapa* under varying field conditions. The variations in moisture and light affected the stomata number on the abaxial leaf surface only. The invasive individuals have increased stomata number feasibly as a part of strategy to increase the CO_2 conductance and plant growth. The higher stomata number has been beneficial under ordinary field conditions in increasing stomatal conductance (Buttery *et al.* 1993).

The plant size of *Mirabilis jalapa* was smaller in the pots and had 2 reproductive phases during one year long life cycle. The first reproductive phase (March to June) had abortive floral buds and did not produce seed. In second reproductive phase (July to December) of pot individuals, the numbers of flowers were higher but, seed setting reduced. In field individuals, the single shorter reproductive phase had very high seed setting rate. Thus, 14 species associated with *Mirabilis jalapa* at Site 1 did not affect the reproductive compatibility of *M. jalapa*. The field individuals of *M. jalapa* not only had vegetative dominance but also increased reproductive or biotic potential. The increase in seed number per individuals of *Mirabilis jalapa* in the field conditions is attributable profusely grown plant body to bear larger number of flowers and seed during shorter favorable conditions (Figure 13). The production of larger number of seeds during shorter single reproductive phase is an invasive trait. In earlier studies, short flowering period (Kollmann and Bañuelos 2004, Richardson 2004) and high reproductive potential (Perrins *et al.* 1992, Thompson *et al.* 1995, Rejmánek and Richardson 1996, Goodwin *et* *al.* 1999, Barrat-Segretain 2005) have been found to be important invasive trait of the species.

The setting of floral buds, flowers and seeds in *Mirabilis jalapa* was very high in field individuals as compared to those cultivated in pots. In cultivated plants, highest floral buds setting (19.2) was recorded in May (Ist phase) and highest seed setting (17.2) in November (IInd phase). But in field individuals (having single reproductive phase), the highest floral bud setting (74.6) was recorded in August and highest seed setting (29.2) in November (Figure 13). From these findings it appears that *M. jalapa* on invasion in the field, produced and partitioned major part of carbon to the reproductive parts for the setting of larger number of seeds and thus expressed r-strategy of survivorship. There is no specific report on the k- and r-strategies of plants with special reference to plant invasion. The higher reproductive potential, long fruiting period and high seed output are strong invasive traits of some plants (Pyšek *et al.* 1995, Rejmánek and Richardson 1996, Williamson and Fitter 1996, Goodwin *et al.* 1999, Rejmánek 2000, Kolar and Lodge 2001, Anonymous 2005). As described earlier (Page 31) *M. jalapa* propagates through seeds and tubers. Due to dual propagation habit, this herbaceous invasive species becomes perennial. Most of perennial species have k-strategies. More work is required to find out if invasive species are capable of changing their survivorship strategies.

The higher vegetative growth in the field may have been an invasive trait to exploit maximum available resource to its benefit as compared to native species. The high nutrient availability in the field may have increased the competitive ability of invasive plants (Wedin and Tilman 1996, Nernberg and Dale 1997, Claassen and Marler 1998). As already described, the soil moisture contents and nutrients (NPK) were relatively lesser in the field as compared to pots (Figure 1 and 2). It is also reported that invader's performance is significantly influenced by resource availability (water, nitrogen, phosphorus and potassium), which influence plant growth positively (Wedin and Tilman 1996, Nernberg and Dale 1997, Claassen and Marler 1998, Milbau and Nijs 2004, Wixted and McGraw 2009). At Site 3, the N, P, K content and soil moisture was higher than at Site 2. Therefore, the *Ruellia tuberosa* had vigorous growth at Site 3 than at Site 2. This further indicates that the selected sites had high invasibility besides the species itself possessed invasive traits.

The ability of *Parthenium hysterophorus* to drive growth advantage from the root exudates of *Mirabilis jalapa* and in turn possible growth suppression of other 14 component species may have been an added benefit for the growth and invasion of *M. jalapa* at Site 1. It is evident from the community study that Site 1 had *P. hysterophorus* but the other three sites in the same field did not (Figure 6, 7 and 8). This specific strategy of *M. jalapa* to have associated with *Parthenium hysterophorus* may have been helpful in establishing the species in the wild habitat. This finding requires further investigation. Similar, traits in some invasive species have been reported earlier (Hay *et al.* 2004, Inderjit *et al.* 2005).

The stomata number on the adaxial surface of the leaf of *Ruellia tuberosa* at Site 3 was low during vegetative phase from April to August and high during reproductive phase from August to February. The increase in the stomata number at reproductive phase appeared to be an ontogenic development rather than environmentally induced characteristics. But low or high moisture and shade (Figure 1) played some role in the density of the stomata in *Mirabilis jalapa* (Figure 12, 28-43 and 44-60). Roggatz *et al.* (1999) reported that the dynamics of stress directly influenced plant ontogeny by influencing the structure and functions of growing tissues. The increase in stomata number was found related with the moisture induced reduction in the size of leaf (Fraser *et al.* 2009).The increase and decrease in stomata number on abaxial surface of leaf of

Mirabilis jalapa appears to be directly related with either very high or very low soil moisture leading to a compact leaf area and reduced epidermal cells size bringing stomata closer. Thus, larger numbers of stomata were focused in one optical field (Figure 12). Similar increase in stomata number with respect to moisture stress has been reported earlier (Schurr *et al.* 2000, Delpérée *et al.* 2003). The decrease in stomata number during flowering season of *Ruellia tuberosa* (July to November) at Site 2 confirm with the earlier findings that leaf morphology changes with leaf expansion in a given season (Parmesan and Yohe 2003, Root *et al.* 2003).

In contrary to *Mirabilis jalapa*, the stem length of *Ruellia tuberosa* decreased at invaded sites (Sites 2 and 3). It may be an adaptive change. Kollmann and Bañuelos (2004) found similar adaptive response of *Impatiens glandulifera* across the nine European regions (Richardson 2004). *Ruellia tuberosa* had multi-seeded fruits. The multi-seeded fruits lead to rapid colonization of plant and this characteristic is an invasive trait (Reichard and Hamilton 1997, Daehler 1998, Sakai *et al.* 2001). Multi-seeded fruits with elaters and light weight seeds having ability of wind dispersal may have been the cause of invasion of *Ruellia tuberosa* at the selected sites.

In pot cultivated individuals of *Ruellia tuberosa*, the flower and floral bud setting was high but seed per pod or average seed output was not as high as in case of individuals of Site 2 and 3. The reduced stem height of *Ruellia tuberosa* with higher seed output in the field (Site 2 and 3) indicate a special adaptive change as an invasive trait. It is also evident that the plants under wild conditions allocated maximum carbon resource to seed component to produce seeds in large numbers as also noted earlier by Stearns (1992).

b) Biological clock

The germination time of *Mirabilis jalapa* growing at invaded site (Site 1) was apparently short as compared to plants cultivated in pots (Figure 14 and 15). The germination of *M. jalapa* at Site 1 was immediately followed by vigorous vegetative growth. While in pots, the seeds sown remained dormant for about one month. After the germination, growth was relatively slower. Short or no seed dormancy is an invasive trait (Anonymous 2005). Relatively fast vegetative growth rate even under low soil moisture indicate that *M. jalapa* had wider ecological amplitude for water requirement. Some species have been found to have wider ecological aptitude for water as invasive trait (Chittka and Schürkens 2001). Fast vegetative growth of *M. jalapa* following germination may also be an invasive strategy of the species to achieve advantage of dominance over native species.

The total reproductive span of both the selected species reduced after invasion in the field. The single flowering phase in wild habitat resulted into fruit and seed setting in *Mirabilis jalapa*. While pot cultivated individuals had one abortive and one productive flowering phase (Figure 14 and 15). Owing to Wide ecological amplitude for soil moisture, *Mirabilis jalapa* compensated by having only single reproductive phase in the field besides having flowering twice in a year under cultivated conditions. The strategy of *M. jalapa* behind reducing reproductive span in the field conditions may have been an invasive trait. All these adaptabilities of *M. jalapa* in a vast set of habitat (moisture, light and temperature) are collectively an invasive character. Similar invasive traits have also noted by Staple *et al.* (2000), Pan *et al.* (2007) and Jia *et al.* (2009). It is evident from the soil analysis that moisture and NPK was adequate at Site 1 in the field. The individuals of *M. jalapa* cultivated in pots had longer life cycle at adequate moisture despite lesser NPK content (Figure 1, 2, 14 and 15). But, in the field shorter life cycle and more vigorous and faster vegetative growth indicate a strong adaptable and invasive character.

The vegetative and reproductive growth span of *Ruellia tuberosa* growing in three variable environments (pot, Sites 2 and 3) varied as evident from their biological clocks (Figure 21, 22 and 23). The germination period of *R. tuberosa* was shorter in the field. The germination was immediately followed by vigorous growth in the field at Site 2 and 3 (Figure 22 and 23). The short germination time is an invasive trait (Milbau and Nijs 2004). Relatively faster vegetative growth under low and medium soil moisture at Site 2 and 3 respectively indicated that *R. tuberosa* had far more wider ecological amplitude for moisture than *Mirabilis jalapa*. The high moisture tolerance or adaptability makes a species more invasive (Chittka and Schürkens 2001). Despite, shorter reproductive span of *Ruellia tuberosa* at invaded sites, plants had more emphasis on seed setting (Figure 21, 22 and 23). The short generation time with high seed production is an important invasive trait (Pyšek *et al.* 1995, Williamson and Fitter 1996, Goodwin *et al.* 1999, Kolar and Lodge 2001).

The optimum water content in soil usually influences growth performance of plant. The soil moisture at Site 2 was lesser than at Site 3 and pots. The moisture content below or beyond the ecological amplitude (10-27%) may have greater influence on most of the growth characteristics (vegetative, reproductive and life cycle). It is also evident from the results of the experiments (Figure 17, 18, 19, 20, 21, 22 and 23) that lower water availability induced early seed setting and reduced span of life cycle. Relatively higher soil moisture at Site 2 increased reproductive span and seed setting in case of *Ruellia tuberosa*. Some of the growth variations may be an out come of phenotypic plasticity. The reduced life cycle span and increased seeds yield may be an adapted invasive strategy.

The *Ruellia tuberosa* having wider ecological amplitude for soil moisture, might have compensated for as low as 10-27% soil moisture by reducing the reproductive span by 1 and 2 months at Site 3 and 2, respectively as compared to individuals grown in pots with adequate moisture. The strategy of *R. tuberosa* behind reducing reproductive span in the field condition may have been a co-evolved adaptive invasive trait. *R. tuberosa* thus appears to have co-evolved with greater extent of adaptability in a vast set of variable habitats (moisture, light and temperature) as is evident from the flexibility in growth and life cycle span. These characteristics have been believed to be invasive character (Staples *et al.* 2000, Pan *et al.* 2007, Jia *et al.* 2009). High seed production and rapid growth (Trisel 1997), high abundance range, good seed dispersal mechanism, rapid response to resource availability and early crop maturity or reduced life span of *Lonicera maackii* (Swab *et al.* 2003) are considered to be invasive traits. All these traits have been recorded in both the selected species.

The soil moisture in pots was adequately maintained but smaller pot size may have been growth constraints for *Mirabilis jalapa*. While the field individuals faced competitive, moisture and space constraints but strategically plant derived growth advantage by early germination followed by the fast vegetative growth. The reproductive span of *M. jalapa* in the field also reduced strategically to a single reproductive flush from July to December. Although, only floral bud formation in the field individuals was recorded from March to June, but all these buds were aborted without flowering, fruiting and seed setting. This indicates that *M. jalapa* strategically reduced its reproductive span in the field and produced respectively larger number of flowers and seeds during a relatively shorter reproductive span (from July to December) in a year. Reduction in the reproductive life span of *M. jalapa* and *R. tuberosa* is invasive characteristic as noted earlier in some other species (Trisel 1997, Swab *et al.* 2003). Fast growth rate reflects rapid acquisition and allocation of resources which enable a plant to simply establish a population following colonization while life history traits predict trade off between high reproduction and growth rates (Stearns 1992). The trade off between reproductive growth and vegetative growth are due to competition for limited resources within an individual (Stearns 1992, McDowell and Radosevich 2005). Some species introduced in a new area tend to flower earlier and longer than in their native habitat (Wolfe *et al.* 2004, Alpert 2006).

c) Survivorship

The studies on life cycle and survivorship under field and pot cultivation showed that *Mirabilis jalapa* invade a new area through seeds. But after its establishment in the field it continued growth as biannual or perennial herbaceous species with life cycle extending between less than a year to 15 months. The new individuals germinated in the field and pots well before the above ground parts of the individuals of the past generation matured. The *M. jalapa* in both the habitats (field and pot) had longer than one year long total life span. The virtual survivorship curve was in between convex to diagonal type (Figure 16). The convex survivorship curve is typical of perennial species and diagonal of biannual species. The observations on field and pot individuals of *M. jalapa* show that species completed its life cycle in a year or earlier but matured plants survived for another three to four months with reduced stem and leaf (after defoliation of large number of branches and leaves). Due to biannual habit, the population of *Mirabilis jalapa* had an oscillatory growth and survivorship curves over the year. Unlike other seasonal native species, *M. jalapa* after invasion established itself as perennial species. The oscillatory pattern of population growth curve and survival is a natural adaptation of a species under direct competition, herbivory or predation following the Gaussian principle of coexistence of species (Kormandy 1996). But after germination or resprouting from old root stocks, the *M. jalapa* had 15 months growth cycle. The convex survivorship curve and perennial habit are part of the k-strategy of the species. The species with k-strategy allocate adequate part of carbon resources to strengthen the structure and functioning of its body (MacArthur and Wilson 1967). Garbey *et al.* (2004) noted three strategies for the survival and growth of *Ranunculus peltatus* in three different habitats. The S-strategy was adopted by the individuals growing in undisturbed (partially shaded soil). In present case, the *M. jalapa* invaded at Site 1 had adequate nutrients and open light and therefore, unlike *R. peltatus*, the plant size of *M. jalapa* and seed production was enhanced indicating that there was no stress. The findings on growth and survival of present studies on *M. jalapa* are in agreement with the C-strategy (competition strategy) of *R. peltatus* having increased its branching and plant size under nutrient rich environment.

As evident from the studies on the effect of light on flowering (Figure 13), the flower and seed number of *Mirabilis jalapa* decreased under shade and enhanced under open light. The reproductive span was single and shorter in the field. This indicates that *M. jalapa* under light variation had the ability to adapt R-strategy as reported earlier in case of *R. peltatus* (Garbey *et al.* 2004). As studied by MacArthur and Wilson (1967), the plants have evolved two major strategies of growth and survival as k- and r-selection. Either of these two strategies are the normal evolutionary trait of native species. But an invasive species may successfully establish itself into a new environment through all or some of the adaptational strategies like C-, S- and R-strategies of *R. peltatus* as studied earlier (Grime 1979, Garbey *et al.* 2004). In the present case, *M. jalapa* appears to have evolved k-selection lines (MacArthur and Wilson 1967) together with C- and R-strategies of adaptation to varying habitats as described by Garbey *et al.* (2004). Thus, *M. jalapa* overcome the competition of native species at invaded site. The high nutrient environment is one of the disturbance factors that lead to plant invasion (Hobbs 1991). Site 1 is a part of the field which had been under cultivation for a long time and the fertility was maintained before it was acquired, fenced and left for few years (Page 31). The invasion of this species at Site 1 in due course modified the environment to be suitable for only 14 component species instead of to 25 species at Site 4 (free from invasion of both the selected species). As described earlier (Pages 92-94), is still not very clear if the patchiness of the native species themselves modified the environment and made the site invasive for the selected species or the selected invasive species had evolved with invasive strategies. But, the findings of the present work suggest that both the factors, the invasibility of sites and invasive traits of plants worked together.

2) Phenotypic Plasticity

The NPK content in the field was higher than in the pot (Figure 2). But *Mirabilis jalapa* had better growth performance in pots maintained with adequate moisture. This shows that *M. jalapa* had to adapt itself under low moisture (at Site 1) through phenotypic plasticity and changes in internal structure and functions.

The number and index of stomata on adaxial and abaxial surfaces of leaf of both the selected plants were positively correlated with number of low moisture stress days (W_4 and W_5, Figure 37 and 38). The leaf area expansion of both the species was directly correlated with number of low moisture days. The degree of steepness (factor b of regression line equation) reduced at low moisture. The leaf number was negatively correlated with the days of low moisture. The relationship of these three factors (leaf number, leaf area and stomata number) indicates that the stomata number in both the selected species at low moisture level increased due to phenotypic plasticity of leaf. The stomata number at high moisture level (W_1) on adaxial and abaxial surfaces of *Ruellia* *tuberosa* was also positively correlated with number of high moisture days. At high moisture level (W_1 and W_2), the plant height (Figure 29), leaf number and leaf area expansion were also positively correlated with the span (days) of high moisture (Figure 30 and 31). This indicate that *Ruellia tuberosa* under high moisture level had ability to increase stomata number besides cell expansion and thus the stomatal conductance has also increased resulting into exponentially increase in plant growth as is evident from the data on plant height (Figure 29).

The stomata number in *Ruellia tuberosa* at W_3 water stress level was negatively correlated with the span of stress (days). But, the leaf area expansion was positively correlated. This indicates that the stomata number was related with the increase in stress days in contrary to the impact of high moisture (W_1) or low moisture (W_5) alone. Therefore, simple increase or decrease in stomata number, leaf area may have been an outcome of internal (cell size) and external (leaf size) morphological plasticity.

High moisture stress (W_4 and W_5) had suppressive effect on reproductive phase. High moisture content (W_1 and W_2) at pre- and post-flowering stage (30 and 60 days after germination) increased number of floral buds, flowers, fruits and average seed output. The high moisture promoted reproductive growth of *Mirabilis jalapa* more prominently as compared to *Ruellia tuberosa* (Figure 32 -35). The low moisture content at pre-flowering stage reduced floral bud setting in *Mirabilis jalapa*. With increase in water stress days, the number of floral buds, flower, fruits and seed output decreased at both the growth stages (Figure 40, 41, 42 and 43). Phenotypic plasticity of floral buds (Nakata and Suehisa 1969, Son *et al.* 1996, Garcia *et al.* 2004), flowers (Westgate and Peterson 1993, Caspari *et al.* 1994, Mills *et al.* 1994b, Behboudian and Mills 1997, Pszczółkowska *et al.* 2003, Barrios *et al.* 2005, Cawoya *et al.* 2006), fruits (Acosta-Gallegos and Adams 1991, Sharma and Sivakumar 1991, Pilbeam *et al.* 1992, Castellanos *et al.* 1996, Lopez *et al.* 1996, Nielson and Nelson 1998, Boutraa and Sanders 2001, Vega *et al.* 2001) and seeds (Shaw and Laing 1966, Singh 1995, Armstrong *et al.* 1996, Desclauxa *et al.* 2000, Guilioni *et al.* 2003, Pszczółkowska *et al.* 2003, French 2006) has been reported in a number of plants in response to water stress. The factor b of regression line indicated that impact of moisture variation was more prominent on the reproductive parameters of *Mirabilis jalapa* as compared to *Ruellia tuberosa* (Figure 40, 41, 42 and 43). The reduction in floral bud number due low moisture may have been caused by alteration in carbon allocation as was noted earlier (Son *et al.* 1996). The delay in flowering of *Mirabilis jalapa* at low soil moisture is in conformity with earlier findings (Craufurd *et al.* 1993, Nakajima *et al.* 1993, Galán 1999, Pradhan *et al.* 2003, Caruso 2006, French 2006). The ability of plant to reduce flowering span or reproductive span as a whole recorded in both the selected species appears to be an adapted invasive trait developed through evolutionary modifications. This trait is expressed under low soil moisture. In contrary, Wolf *et al.* (2004) and Alpert (2006) reported that the some introduced species in a new area tend to flower earlier and for longer duration than in their native habitats. But on the other hand, relatively better vegetative growth of *Ruellia tuberosa*, at Site 3 as compared to Site 2 appears to be directly related with the reduced soil moisture and light regimes (Figure 2 and 3) at both the sites. It is evident from the findings of Merchant (1998), Baruch *et al.* (2000) and Stanton and DiTomaso (2004) that stem height, leaf number, leaf area, stem biomass and relative growth rate of some invasive plants decreased with decreased with soil moisture and light. Thus the plants have two evolutionary lines.

The decrease in stomata number and indices may have resulted out of excessive expansion of leaves in well water plants leading to the enlargement of epidermal cells and thereby reduced stomata per focus (Jones 1992, Beerling *et al.* 1993, Wang *et al.*

2007, Fraser *et al.* 2009). Under dry conditions (W_4 and W_5), the stomata number on abaxial surface increased feasibly due to reduction in leaf size and reduced epidermal cells brought the stomata closer to each other. Similar decrease and increase in stomata number related to moisture level has been reported recently (Fraser *et al.* 2009). Chen and When (2005) reported, increase in stomata number in *Phellodendron amarense* at low soil moisture. While Ratnayaka and Kincaid (2005) reported, decrease in stomata number in *Cassio angustifolia* at low soil moisture feasibly due to direct impact on stomata development.

The light and shade also influence the stomata number, CO_2 exchange and other functions (Delpérée *et al.* 2003, Zhan *et al.* 2005, Hovenden and Vander Schoor 2006). Increased stomata number in *M. jalapa* (Figure 52A-C and 53A-C) and decreased in *R. tuberosa* (Figure 52D-F and 53 D-F) was recorded in plants kept under shade. Delpérée *et al.* (2003) and Zhan *et al.* (2005) found decreased stomata number in shade. But in some species, stomata number increased under shade (Hovenden and Vander Schoor 2006). The stomata number on the adaxial surface of leaf of *Ruellia tuberosa* decreased at Site 2 and increased at Site 3. The moisture content and shade at Site 2 was lower than at Site 3. Therefore, there is no general agreement over the response of stomata number with reference to soil moisture or shade. In the present study also both the selected species varied in specific response of stomata number with reference to soil moisture and shade. Both the selected species may have differed in their lines of evolution. But variation in stomata number in response to moisture and shade appears to be a sensitive trait and many have related with functional adaptations. The shade and soil moisture are known to modify the impact of each other. The increase and decrease in stomata number and resulting change in the plant functions needs to be emphasized in future studies.

The invasive species having structural and functional plasticity may have tolerance for light and water stress and favored their invasion. The invasive terrestrial plants high tolerance against environmental extremes (Anonymous 2005). The invasibility of susceptibility or the habitat of selected species, our findings match with the classification of the findings of Wilson *et al.* (1992), Collingham *et al.* (2000) and Kriticos *et al.* (2003). The factors for the success of species at local level are land use (Pauchard and Alaback 2004), soil (Ohlemüller *et al.* 2005), disturbance (Bellingham 1998), mutualism (Parker 1997), facilitation (Williams and Karl 1996), competition (Levine 2000) and at site level are soil (Harrison 1999), disturbance (Lake and Leishman 2004), mutualism (Chittka and Schürkens 2001), facilitation (Reinhart *et al.* 2006), competition (Foster *et al.* 2002) and resources (Maron and Jefferies 1999).

Conclusion

CONCLUSION

The invasion of plants depends upon invasibility or susceptibility of the ecosystems and invasive traits of invaders suitable for the available ecosystem. In the present study, the invasibility of a field and invasive traits of 2 species was studied with special reference to the adaptability of species to variable soil moisture conditions. The impact of some factors like light, root exudates of the host community and structure of the community have also been studied and compared.

It emerged from the findings that plant invasion are govern by the susceptibility of the ecosystem, invasive traits of the species and facilitation by the host community. The patchiness present in the field due to dominance of variable native species may have made available certain vacant niches for the occupation by the invasive species. The species having adequate adaptations to water stressed conditions may have been suitable settlers.

As noted in the present study, *Mirabilis jalapa* reduced the reproductive span but increased seed production under stressed conditions of field. The tuberous storage roots helped them as buffers for water stress conditions. *M. jalapa* developed invasive ties with *Parthenium hysterophorus*. The root exudates of *Parthenium* did not affect the growth of *M. jalapa* instead provided cover and shade to newly germinated seedlings of *M. jalapa* in the month of January. The root exudates of *M. jalapa* on the other hand promoted the growth of *Parthenium hysterophorus*. Thus prior invasion of *Parthenium* caused invasional meltdown and led to the invasion of *M. jalapa*. After the invasion of *M. jalapa*, both the species developed mutualism.

As evident from the summary tables the moisture stress reduced plant height, leaf number, leaf area, relative water content and stomata number in *Mirabilis jalapa* and

Ruellia tuberosa. But root exudates of selected component species did not affect the growth of both the species. Shade enhanced some growth parameters in *M. jalapa* but decreased in *R. tuberosa*. This indicates that *M. jalapa* preferred mesophytic conditions and *R. tuberosa* has higher adaptation to xerophytic conditions. The stomata number and leaf tissue area in both the species had greater adaptability to variable light and showed reduction in response to shade. A comparative account of the responses of both the selected species revealed that *M. jalapa* had greater affinity to invasion as the vegetative and reproductive growth increased under field conditions as compared to pot. But, *R. tuberosa* developed adaptability to xeric conditions with some growth reductions.

The *Ruellia tuberosa* preferred drier parts of the field for the invasion. The water stressed conditions first reduced the species diversity in direr parts of the field and increased the invasibility of the stress tolerant *Ruellia tuberosa*. The water scarcity may be considered as a disturbance. The stomata number in *Mirabilis jalapa* increased at their respective sites which in turn increased the CO_2 intake and fixation. The higher CO_2 intake and fixation at early stage may have caused greater nutrient uptake by *M. jalapa* as compared to native species.

It may be inferred that the autecological studies in all ranges of invasive species environment may prove to be helpful in working out specific invasive traits of the species and possible invasibility of ecosystem. Such studies may be helpful in developing models of plants invasion at local, regional and continental scales. The autecological life cycles of both the species have been helpful in the assessment of overall adaptability of the species by means of reductions in the span of the life cycles and corresponding increase in the seed output under field conditions. Thus the autecological studies shall be emphasized for drawing sound conclusions related to invasive traits of the species.

Some of the common invasive traits in both the species are reduction in the span of life cycle, adaptability to water stress conditions specifically in *Ruellia tuberosa*, ability of invasional metdown by *Mirabilis jalapa* through *Parthenium hysterophorus* and plasticity in the development and function of stomata under stressed field condition. The fasciculated roots of *M. jalapa* served as food reservoir. Faster growth of *M. jalapa* soon after germination and high reproductive capacity during short reproductive phase were the invasive traits. The field under extreme drought were susceptible for the invasion of *R. tuberosa* and occasional increase in soil moisture increased the invasibility of the field for *M. jalapa*.

Summary

SUMMARY

In the present work autecology including life cycle of two invasive plants namely *Mirabilis jalapa* and *Ruellia tuberosa* has been studied at selected invaded sites to workout adaptations and evolved morpho-physiological changes. *Mirabilis jalapa* (Nyctaginaceae) and *Ruellia tuberosa* (Acanthaceae) are garden escapes. The changes in the autecology and life cycles of both the selected plants growing wild were compared with pot grown plants. The community structure of invaded sites has been compared with the community structure of non-invaded sites in the same selected field. The study also includes screening of invasive traits of both the species and invasibility of the selected field or ecosystem. The community structure of the invaded sites was studied to workout relative impact of their invasion. Most of the plants after escape from cultivated to wild environment face moisture constraints besides other community attribute. The pot studies were conducted to workout growth variations in both the selected species with special reference to water stress. Besides these, the effect of varying light regimes and impact of root exudates of selected native species of the invaded community on the growth of both the species was also studied and compared to work out their response and adaptability.

The present studies were conducted in an agriculture field deserted for about 10 years. The selected field (6.97 hectares) is a fertile land and had been under cultivation until the Aligarh Muslim University acquired it in 1997. The field stretches to about 410 m in length and 170 m in width. The rain water continued to drain through the deserted and ruined water channels of the field and increased the soil moisture around it. The acquired area was enclosed by boundary walls and barbed wire fencing. The land after acquiring remained free from all human activities by the court orders. Thus the entire

field thus remained open for free invasion of native and invasive plants growing wild or cultivated around these. In the whole area 33 woody and herbaceous species have since invaded and established. At the time of acquiring the field, few trees of *Mangifera indica* and *Dalbergia sissoo* were already present. Among wild plants, *Mirabilis jalapa* and *Ruellia tuberosa* were the invasive species besides *Parthenium hysterophorus*. The invasibility of *Parthenium* sp. in various ecosystems has been extensively studied in India since 1960's. The invasibility of *Mirabilis jalapa* and *Ruellia tuberosa* has not been worked out thoroughly with reference to soil moisture and other factors. Moreover, the invasive traits of both the selected species and characteristics of invasible field are also not well known.

The selected field had patches of micro-climatic variations (soil moisture and shade). During survey of the selected field *Mirabilis jalapa* was found growing around the ruined water channels having relatively higher soil moisture. The patch was selected as Site 1 and two other patches of community with *Ruellia tuberosa* were selected as Sites 2 and 3. A patch of non-invaded site in the same field was also selected as Site 4. The seeds of both the species were collected from an adjoining field where these species were being cultivated as ornamentals. The seed of cultivated populations were used for pot studies. The population of selected plants growing in the selected field appeared to be the escapes of the population under cultivation. Thus some traits of cultivated and wild plants were compared to find out adapted growth variations of both the species.

In the selected field, *Mirabilis jalapa* germinates in the month of January. But in pots seeds germinated in the month of February. The *Ruellia tuberosa* germinates in the month of April at both the selected sites (2 and 3) but few seeds unusually germinated in the month of July as well. The later germinated seedlings of *Ruellia tuberosa* were short lived.

The studies were conducted at monthly intervals. The comparative account of the data show that the plant height and leaf number of *Mirabilis jalapa* was larger in the field as compared to those grown in pots. The plant height, leaf number, total leaf area and leaf size of *Ruellia tuberosa* decreased at invaded sites as compared to plants grown in pot. The relative water content and chlorophyll content in the leaves of both the selected plants (field or pot grown) had no statistical difference. The stomata number on adaxial and abaxial surfaces of leaf of *Ruellia tuberosa* reduced in the field individuals as compared to the individuals of pot maintained with adequate soil moisture. But, *Mirabilis jalapa* developed stomata on the adaxial surface at Site 1 which were otherwise absent in pot individuals. The total amount of tissues per unit leaf area increased in *Mirabilis jalapa* at Site 1. The above ground biomass, floral bud number, fruit number, average seed output and reproductive capacity also increased in *Mirabilis jalapa* at Site 1 and decreased in *Ruellia tuberosa* (at Site 2 and 3).

Effect of Variable Moisture

The pot studies with variable soil moisture showed that the plant height, leaf number, leaf area expansion, chlorophyll content reduced in both the species at low moisture content. But stomata number increased as low soil moisture in pots. The above ground biomass, floral buds, flowers and fruits per plants as well as average seed output reduced in both the species at low moisture content indicating that low moisture content limits both vegetative and reproductive growth of both the species. But, even then *Mirabilis jalapa* had vigorous growth in the field.

The shade increased plant height, leaf area expansion rate, stomata number in *Mirabilis jalapa*, but total leaf tissue area, above ground biomass and reproductive parameters decreased. The root exudates of three component species at Site 1 did not affect any vegetative or reproductive growth parameters of *Mirabilis jalapa* when treated under open light with adequate moisture.

Ruellia tuberosa appeared to be more sensitive to moisture content and light as compared to *Mirabilis jalapa*. The root exudates of component native species did not affect *Ruellia tuberosa*. The low moisture reduced plant height, leaf number, leaf area expansion rate, chlorophyll content, above ground biomass, floral buds, flowers, fruits and average seed output. The shade also reduced plant height, leaf number, leaf area expansion rate, stomata number, total leaf tissue area, above ground biomass and other reproductive parameters.

The soil analysis revealed that high nutrient content and organic matter in the field increased the invasibility of selected sites for *Mirabilis jalapa*. Despite low moisture in the field (as compared to pots) *Mirabilis jalapa* had better growth. The adaptability of fruit setting, average seed output, reproductive capacity, floral bud setting, above ground biomass, shorter reproductive life span in field in accordance with favorable climatic variations were the important invasive characteristics of *Mirabilis jalapa*. Better growth behavior in field despite moisture stress indicated that tuberous tap roots of *Mirabilis jalapa* occupied a different rhizosphere niche. The plant height of *Ruellia tuberosa* at Sites 2 and 3 reduced in comparison to pot cultivated plants. The moisture played important role in reproductive performance of *Ruellia tuberosa* at two sites, as was also evident from the pot experiments on *Ruellia tuberosa* with variable moisture.

On a comparison of the life cycle, it appeared that *Mirabilis jalapa* strategically had single and shorter but most effective reproductive phase at Site 1 in comparison to pot. In *Ruellia tuberosa* the total span of life cycle and span of reproductive phase reduced in the field to adapt with the available growth attributes. Moisture variation at Sites 2 and 3 directly affected the span of reproductive phase of *Ruellia tuberosa.* The span of life cycle of *Ruellia tuberosa* was of 12 months in pots maintained with adequate moisture, but 11 months at Site 3 and 10 months at Site 2. The span of life cycle was in conformity with the soil moisture. The variation in reproductive parameters was also influenced by shade and low moisture. The vegetative and reproductive growth parameters of *Ruellia tuberosa* reduced in shade as well. Therefore, the reduction in plant height of *Ruellia tuberosa* may have been jointly influenced by reduced luminance and moisture content at Sites 2 and 3. From field and pot studies, it is evident that *Mirabilis jalapa* had relatively wider ecological amplitude than *Ruellia tuberosa* and therefore former appears to be a long persisting invasive species than the later.

Invasive Characteristics of Both the Species

The invasive characteristics of both the selected species as worked out in the present study are listed against each species.

Mirabilis jalapa : Good adaptability with component native species, adaptability to low moisture, rapid and vigorous growth immediately after germination, reduced flowering span, high reproductive potential, high survivorship under environmental adversities in field, ability to explore available nutrients to its maximum benefit, wide ecological amplitude (for water stress) and ability of invasional meltdown through *Parthenium hysterophorus.*

Ruellia tuberosa : Moderate adaptability with native component species, rapid growth, short flowering time, vigorous vegetative and reproductive growth in field conditions, decreased plant size, high reproductive potential, multiseeded fruits, high survivorship under in field, moderately wide ecological amplitude for soil moisture and shade.

Invasibility of Ecosystem

The comparison of the characteristics of the selected sites and pots showed that high nutrient content in the selected field, just adequate moisture and open light made the Site 1 of the ecosystem highly invasible for *Mirabilis jalapa*. High nutrients (NPK), shade and relatively low moisture proved to be cause of invasion of *Ruellia tuberosa* at Sites 2 and 3. All the selected sites remained undisturbed for long and therefore, the invasion of both the selected species was not found related with the disturbance regime in contrary to earlier findings. The invasion of *Parthenium hysterophorus* caused invasion meltdown and made the Site 1 invasible for *Mirabilis jalapa*. The root exudates of selected native species did not affect the growth and establishment of both the selected invasive species at their respective invaded sites. The low moisture at Site 2 and 3 may have checked the invasion of *Ruellia tuberosa* but the adaptability of species to reduce its life cycle under limited water stress kept the Sites 2 and 3 invasible.

It is inferred from the findings that besides possession of invasive characteristics, the invasibility of ecosystem is equally imported for plant invasions. The moisture, nutrient availability and adequate light availability are important for plant invasion in a given ecosystem besides the invasive characteristics. The invasion meltdown or positive relationship of a invasive species with another alien species as 'enemy of enemy is a friend' may be taken as a joint characteristics (as invasive traits of the species and invasibility of such ecosystems).

Table A. Changes in the growth of ***Mirabilis jalapa*** at Site **1** and ***Ruellia tuberosa*** at Site **2** and **3** in comparison to plant growth in pots (summary of Tables 24 to 28).

S. No.	Parameters	Site 1	Site 2	Site 3
1.	Germination	January (February in pots)	April and unusual in July	April and unusual in July
2.	Plant height	Increased	Decreased	Decreased
3.	Leaf number	-do-	-do-	-do-
4.	Leaf area	Decreased	-do-	-do-
5.	Total leaf area	-do-	-do-	-do-
6.	Relative water content, Chlorophyll content (a, b and total)	No response chlorophyll content decreased (June and July)	No response chlorophyll content decreased	No response chlorophyll content decreased
7.	Stomata number and index (adaxial surface)	Developed from January to June (Absent in pots)	Decreased	Marginal decreased
8.	Stomata number and index (abaxial surface)	Decreased	-do-	Decreased
9.	Total leaf tissue area	Increased	Increased	Decreased
10.	Above ground biomass	-do-	Decreased	Decreased
11.	Floral bud number	-do-	-do-	-do-
12.	Flower number	Almost same	-do-	-do-
13.	Fruit number	Increased	-do-	-do-
14.	Average seed output	-do-	Decreased	Marginal decreased

Table B. Impact of varying factors on the growth of ***Mirabilis jalapa*** treated at varying growth stages (30 and 60 days after germination) and studied up to 35 days (summary of Tables 29 to 76).

S. No.	Parameters	Stages	Responses for varying factors		
			Moisture	**Light**	**Root exudate**
1.	Plant height (cm)	30DAG	Reduced at W_3, W_4 and W_5	Increased in shade	NS
		60DAG	-do-	NS	NS
2.	Leaf number per plant	30DAG	-do-	Reduced in shade	NS
		60DAG	-do-	-do-	NS
3.	Leaf area expansion per plant	30DAG	-do-	Increased in shade	NS
		60DAG	-do-	-do-	NS
4.	Relative water content, Chlorophyll content (a, b and total)	30DAG	-do-	NS	NS
		60DAG	-do-	NS	NS
5.	Stomata number and index (adaxial surface)	30DAG	-	Increased in shade	NS
		60DAG	-	-do-	NS
6.	Stomata number and index (abaxial surface)	30DAG	Reduced at W_3 and Increased at W_4-W_5	Number increased and index decreased	NS
		60DAG	-do-	-do-	NS
7.	Total leaf tissue area	30DAG	Increased at low moisture	Reduced in shade	NS
		60DAG	-do-	-do-	NS
8.	Above ground biomass	30DAG	Reduced at W_3, W_4 and W_5	Reduced in shade	NS
		60DAG	-do-	NS	NS
9.	Number of floral buds, flowers and fruits	30DAG	-do-	Decreased in partial light and shade	NS
		60DAG	-do-	-do-	NS
10.	Average seed output	60DAG	-do-	-do-	NS

DAG–Days after germination

Table C. Impact of varying factors on the growth of ***Ruellia tuberosa*** treated at varying growth stages (30 and 60 days after germination) and studied up to 35 days (summary of Tables 29 to 61 and 77 to 93).

S. No.	Parameters	Stages	Responses for varying factors		
			Moisture	**Light**	**Root exudate**
1.	Plant height (cm)	30DAG	Reduced at W_3, W_4 and W_5	Reduced in shade	NS
		60DAG	-do-	NS	NS
2.	Leaf number per plant	30DAG	-do-	Reduced in shade	NS
		60DAG	-do-	-do-	NS
3.	Leaf area expansion per plant	30DAG	-do-	Decreased in shade	NS
		60DAG	-do-	-do-	NS
4.	Relative water content, Chlorophyll content (a, b and total)	30DAG	Reduced except Chlorophyll-b NS	NS	NS
		60DAG	Reduced except Chlorophyll-a and b NS	NS	NS
5.	Stomata number and index (adaxial surface)	30DAG	Reduced at W_3 and Increased at W_4-W_5	Decreased in shade	NS
		60DAG	-do-	-do-	NS
6.	Stomata number and index (abaxial surface)	30DAG	Reduced at W_3 and Increased at W_4-W_5	Number decreased and index increased	NS
		60DAG	-do-	-do-	NS
7.	Total leaf tissue area	30DAG	Increased at low moisture	Reduced in shade	NS
		60DAG	-do-	-do-	NS
8.	Above ground biomass	30DAG	Reduced at low moisture	Reduced in shade	NS
		60DAG	NS	NS	NS
9.	Number of floral buds, flowers and fruits	30DAG	-do-	Decreased in partial light and shade	NS
		60DAG	-do-	-do-	NS
10.	Average seed output	60DAG	-do-	-do-	NS

DAG–Days after germination

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Annexure

Table 3. Abundance of component species at Site 1 invaded by *Mirabilis jalapa* (presented as Figure 4A).

Plant species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean±SD
Abutilon indica	–	–	–	1.00	1.00	1.50	1.50	1.50	1.50	2.00	1.50	1.50	$1.44^{ns}\pm0.28$
Acalypha indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Achyranthes aspera	3.00	–	–	–	–	–	–	–	–	–	2.00	2.00	$2.33^{ns}\pm0.47$
Aerva species	–	–	–	–	–	–	–	–	–	–	–	–	–
Ageratum conyzoides	–	–	–	–	–	–	–	–	–	–	–	–	–
Allernanthera pungenus	–	–	–	–	–	1.00	–	–	–	–	–	–	1.00±0.00
Amaranthus viridis	–	–	2.00	–	–	–	2.50	–	1.50	1.00	–	–	1.75*±0.56
Argemone mexicana	1.00	1.50	1.00	1.50	–	–	1.00	–	–	–	–	2.00	$1.33^{ns}\pm0.37$
Bidens pilosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Brachiaria ramosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Capparis sepiaria	–	–	–	–	–	–	–	–	–	–	–	–	–
Cenchrus ciliaris	–	–	–	–	–	–	–	–	–	–	–	–	–
Chenopodium album	–	–	2.00	2.00	–	–	–	–	–	–	–	–	$2.00^{ns}\pm0.00$
Dichanthium annulatum	–	–	–	–	–	–	–	–	–	–	–	–	–
Eclipta prostrata	–	–	–	–	–	–	–	–	–	–	–	–	–
Erigeron bonariensis	–	–	–	–	–	–	–	–	–	–	–	–	–
Euphorbia hirta	–	–	–	–	–	–	–	–	–	–	–	–	–
Malvastrum coromandelianum	1.20	1.00	2.00	1.50	1.00	1.00	1.00	1.50	2.00	1.50	3.00	–	1.52*±0.59
Mirabilis jalapa	**1.20**	**1.80**	**2.60**	**3.20**	**3.00**	**2.80**	**3.20**	**2.40**	**2.00**	**2.00**	**1.80**	**1.80**	**2.32±0.62**
Oxalis corniculata	–	–	–	–	–	–	–	–	–	–	–	–	–
Parthenium hysterophorus	1.00	1.50	1.67	1.60	1.80	1.60	1.60	1.75	2.00	1.40	3.00	1.67	1.72±0.45
Peristrophe paniculata	–	–	–	–	–	–	–	–	–	–	–	–	–
Primula species	–	–	–	–	–	–	–	1.50	–	–	–	–	1.50*±0.00
Ruellia tuberosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Rumex dentatus	–	–	–	1.00	–	–	1.00	–	–	–	–	–	1.00±0.00
Scoparia dulcis	–	–	–	–	2.00	–	–	–	–	–	–	–	2.00*±0.00
Setaria species	–	–	–	–	–	–	–	–	–	–	–	–	–
Sida rhombifolia	–	–	2.00	1.00	–	–	–	–	1.50	1.28	–	–	$1.45^{ns}\pm0.37$
Solanum nigrum	–	1.50	–	1.00	–	–	–	–	–	–	–	–	1.25*±0.25
Sonchus oleraceus	–	–	–	–	–	–	–	–	–	–	–	–	–
Trianthema portulacastrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Vernonia cinerea	–	–	–	–	–	–	–	–	–	–	–	–	–
Unidentified Acanthaceae	–	–	1.00	–	–	1.50	–	–	–	–	–	–	1.25±0.25

Table 4. Relative frequency of component species at Site 1 invaded by *Mirabilis jalapa* (presented as Figure 4B).

Plant species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean±SD
Abutilon indica	–	–	–	40.00	40.00	40.00	80.00	80.00	40.00	20.00	40.00	40.00	$46.67^{ns}\pm18.86$
Acalypha indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Achyranthes aspera	20.00	–	–	–	–	–	–	–	–	–	20.00	40.00	$26.67^{*}\pm9.43$
Aerva species	–	–	–	–	–	–	–	–	–	–	–	–	–
Ageratum conyzoides	–	–	–	–	–	–	–	–	–	–	–	–	–
Allernanthera pungenus	–	–	–	–	–	40.00	–	–	–	–	–	–	40.00 ± 0.00
Amaranthus viridis	–	–	20.00	–	–	–	40.00	–	40.00	60.00	–	–	$40.00^{*}\pm14.14$
Argemone mexicana	20.00	80.00	20.00	40.00	–	–	20.00	–	–	–	–	20.00	$33.33^{ns}\pm22.11$
Bidens pilosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Brachiaria ramosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Capparis sepiaria	–	–	–	–	–	–	–	–	–	–	–	–	–
Cenchrus ciliaris	–	–	–	–	–	–	–	–	–	–	–	–	–
Chenopodium album	–	–	20.00	40.00	–	–	–	–	–	–	–	–	$30.00^{*}\pm10.00$
Dichanthium annulatum	–	–	–	–	–	–	–	–	–	–	–	–	–
Eclipta prostrata	–	–	–	–	–	–	–	–	–	–	–	–	–
Erigeron bonariensis	–	–	–	–	–	–	–	–	–	–	–	–	–
Euphorbia hirta	–	–	–	–	–	–	–	–	–	–	–	–	–
Malvastrum coromandelianum	100.00	40.00	20.00	40.00	40.00	40.00	20.00	40.00	20.00	40.00	40.00	–	$40.00^{*}\pm20.89$
Mirabilis jalapa	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00±0.00**
Oxalis corniculata	–	–	–	–	–	–	–	–	–	–	–	–	–
Parthenium hysterophorus	60.00	60.00	60.00	100.00	100.00	100.00	100.00	80.00	80.00	100.00	60.00	60.00	80.00 ± 18.26
Peristrophe paniculata	–	–	–	–	–	–	–	–	–	–	–	–	–
Primula species	–	–	–	–	–	–	–	40.00	–	–	–	–	$40.00^{ns}\pm0.00$
Ruellia tuberosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Rumex dentatus	–	–	–	20.00	–	–	20.00	–	–	–	–	–	20.00 ± 0.00
Scoparia dulcis	–	–	–	–	40.00	–	–	–	–	–	–	–	$40.00^{*}\pm0.00$
Setaria species	–	–	–	–	–	–	–	–	–	–	–	–	–
Sida rhombifolia	–	–	20.00	20.00	–	–	–	–	40.00	80.00	–	–	$40.0^{ns}\pm24.49$
Solanum nigrum	–	40.00	–	20.00	–	–	–	–	–	–	–	–	$30.00^{*}\pm10.00$
Sonchus oleraceus	–	–	–	–	–	–	–	–	–	–	–	–	–
Trianthema portulacastrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Vernonia cinerea	–	–	–	–	–	–	–	–	–	–	–	–	–
Unidentified Acanthaceae	–	–	20.00	–	–	80.00	–	–	–	–	–	–	$50.00^{ns}\pm30.00$

Table 5. Relative density of component species at Site 1 invaded by *Mirabilis jalapa* (presented as Figure 4C).

Plant species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean±SD
Abutilon indica	–	–	–	5.40	6.25	8.57	15.79	18.35	10.35	6.67	10.35	13.04	10.53^{ns}±4.20
Acalypha indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Achyranthes aspera	15.79	–	–	–	–	–	–	–	–	–	6.90	17.39	13.36^{ns}±4.61
Aerva species	–	–	–	–	–	–	–	–	–	–	–	–	–
Ageratum conyzoides	–	–	–	–	–	–	–	–	–	–	–	–	–
Allernanthera pungenus	–	–	–	–	–	5.71	–	–	–	–	–	–	5.71±0.00
Amaranthus viridis	–	–	3.57	–	–	–	13.16	–	10.35	10.00	–	–	9.27^{ns}±3.51
Argemone mexicana	5.26	26.10	3.57	8.11	–	–	2.63	–	–	–	–	8.70	9.06*±7.93
Bidens pilosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Brachiaria ramosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Capparis sepiaria	–	–	–	–	–	–	–	–	–	–	–	–	–
Cenchrus ciliaris	–	–	–	–	–	–	–	–	–	–	–	–	–
Chenopodium album	–	–	7.14	5.40	–	–	–	–	–	–	–	–	6.27^{ns}±0.87
Dichanthium annulatum	–	–	–	–	–	–	–	–	–	–	–	–	–
Eclipta prostrata	–	–	–	–	–	–	–	–	–	–	–	–	–
Erigeron bonariensis	–	–	–	–	–	–	–	–	–	–	–	–	–
Euphorbia hirta	–	–	–	–	–	–	–	–	–	–	–	–	–
Malvastrum coromandelianum	31.58	8.70	7.14	8.11	3.13	5.71	2.63	9.68	6.90	10.00	20.69	–	10.39^{ns}±8.10
Mirabilis jalapa	**31.58**	**39.14**	**46.40**	**43.20**	**50.00**	**40.00**	**42.10**	**38.70**	**34.48**	**33.30**	**31.03**	**39.13**	**39.09±5.59**
Oxalis corniculata	–	–	–	–	–	–	–	–	–	–	–	–	–
Parthenium hysterophorus	15.79	13.04	21.43	21.62	28.13	22.86	21.05	22.58	27.59	23.33	31.03	21.74	22.52±4.75
Peristrophe paniculata	–	–	–	–	–	–	–	–	–	–	–	–	–
Primula species	–	–	–	–	–	–	–	9.68	–	–	–	–	9.68*±0.00
Ruellia tuberosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Rumex dentatus	–	–	–	2.70	–	–	2.63	–	–	–	–	–	2.67±0.04
Scoparia dulcis	–	–	–	–	12.50	–	–	–	–	–	–	–	12.50*±0.00
Setaria species	–	–	–	–	–	–	–	–	–	–	–	–	–
Sida rhombifolia	–	–	7.14	2.70	–	–	–	–	10.35	16.67	–	–	9.22^{ns}±5.09
Solanum nigrum	–	13.04	–	2.70	–	–	–	–	–	–	–	–	7.87^{ns}±5.17
Sonchus oleraceus	–	–	–	–	–	–	–	–	–	–	–	–	–
Trianthema portulacastrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Vernonia cinerea	–	–	–	–	–	–	–	–	–	–	–	–	–
Unidentified Acanthaceae	–	–	3.60	–	–	17.14	–	–	–	–	–	–	10.37^{ns}±6.77

Table 6. Relative dominance of component species at Site 1 invaded by *Mirabilis jalapa* (presented as Figure 4D).

Plant species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean±SD
Abutilon indica	–	–	–	12.53	9.28	5.40	11.98	16.31	8.83	2.22	7.36	15.75	9.96*±1.55
Acalypha indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Achyranthes aspera	5.70	–	–	–	–	–	–	–	–	–	12.09	6.81	8.20*±1.97
Aerva species	–	–	–	–	–	–	–	–	–	–	–	–	–
Ageratum conyzoides	–	–	–	–	–	–	–	–	–	–	–	–	–
Allernanthera pungenus	–	–	–	–	–	4.60	–	–	–	–	–	–	4.60±0.00
Amaranthus viridis	–	–	3.57	–	–	–	2.16	–	3.69	4.67	–	–	3.52^{ns}±0.52
Argemone mexicana	1.32	4.32	6.63	6.89	–	–	2.25	–	–	–	–	5.11	4.42^{ns}±0.93
Bidens pilosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Brachiaria ramosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Capparis sepiaria	–	–	–	–	–	–	–	–	–	–	–	–	–
Cenchrus ciliaris	–	–	–	–	–	–	–	–	–	–	–	–	–
Chenopodium album	–	–	8.16	2.09	–	–	–	–	–	–	–	–	5.13^{ns}±3.04
Dichanthium annulatum	–	–	–	–	–	–	–	–	–	–	–	–	–
Eclipta prostrata	–	–	–	–	–	–	–	–	–	–	–	–	–
Erigeron bonariensis	–	–	–	–	–	–	–	–	–	–	–	–	–
Euphorbia hirta	–	–	–	–	–	–	–	–	–	–	–	–	–
Malvastrum coromandelianum	15.35	1.54	3.06	1.88	0.66	2.50	2.93	2.18	8.94	13.33	4.21	–	5.14^{ns}±1.52
Mirabilis jalapa	**71.49**	**80.86**	**38.78**	**35.46**	**62.34**	**60.20**	**57.12**	**63.33**	**81.45**	**61.56**	**51.64**	**38.72**	**58.58±4.44**
Oxalis corniculata	–	–	–	–	–	–	–	–	–	–	–	–	–
Parthenium hysterophorus	6.14	12.35	30.10	34.04	22.44	20.48	20.63	17.90	3.69	13.11	24.70	33.61	19.93±2.86
Peristrophe paniculata	–	–	–	–	–	–	–	–	–	–	–	–	–
Primula species	–	–	–	–	–	–	–	0.25	–	–	–	–	–
Ruellia tuberosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Rumex dentatus	–	–	–	4.18	–	–	2.93	–	–	–	–	–	3.56±0.63
Scoparia dulcis	–	–	–	–	8.24	–	–	–	–	–	–	–	–
Setaria species	–	–	–	–	–	–	–	–	–	–	–	–	–
Sida rhombifolia	–	–	8.16	0.21	–	–	–	–	1.45	5.11	–	–	3.73^{ns}±1.81
Solanum nigrum	–	0.93	–	2.72	–	–	–	–	–	–	–	–	1.83^{ns}±0.90
Sonchus oleraceus	–	–	–	–	–	–	–	–	–	–	–	–	–
Trianthema portulacastrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Vernonia cinerea	–	–	–	–	–	–	–	–	–	–	–	–	–
Unidentified Acanthaceae	–	–	1.53	–	–	6.69	–	–	–	–	–	–	4.11^{ns}±2.58

Table 7. Important value index of component species at Site 1 invaded by *Mirabilis jalapa* (presented as Figure 4E).

Plant species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean±SD
Abutilon indica	–	–	–	57.94	56.00	119.22	107.80	115.00	59.00	29.00	58.00	69.00	74.55^{ns}±10.53
Acalypha indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Achyranthes aspera	41.50	–	–	–	–	–	–	–	–	–	39.00	64.20	48.23*±8.02
Aerva species	–	–	–	–	–	–	–	–	–	–	–	–	–
Ageratum conyzoides	–	–	–	–	–	–	–	–	–	–	–	–	–
Allernanthera pungenus	–	–	–	–	–	46.21	–	–	–	–	–	–	46.21±0.00
Amaranthus viridis	–	–	27.10	–	–	–	55.32	–	54.00	74.00	–	–	52.61^{ns}±9.65
Argemone mexicana	26.60	110.40	30.20	55.00	–	–	24.88	–	–	–	–	33.81	46.82*±13.47
Bidens pilosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Brachiaria ramosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Capparis sepiaria	–	–	–	–	–	–	–	–	–	–	–	–	–
Cenchrus ciliaris	–	–	–	–	–	–	–	–	–	–	–	–	–
Chenopodium album	–	–	35.30	47.49	–	–	–	–	–	–	–	–	41.40^{ns}±6.10
Dichanthium annulatum	–	–	–	–	–	–	–	–	–	–	–	–	–
Eclipta prostrata	–	–	–	–	–	–	–	–	–	–	–	–	–
Erigeron bonariensis	–	–	–	–	–	–	–	–	–	–	–	–	–
Euphorbia hirta	–	–	–	–	–	–	–	–	–	–	–	–	–
Malvastrum coromandelianum	147.00	50.20	30.20	50.00	24.79	48.00	26.00	52.00	36.00	63.00	64.00	–	53.74^{ns}±10.19
Mirabilis jalapa	**203.10**	**220.00**	**185.00**	**178.70**	**212.00**	**158.00**	**179.00**	**202.00**	**216.00**	**195.00**	**183.00**	**178.00**	**192.48±5.38**
Oxalis corniculata	–	–	–	–	–	–	–	–	–	–	–	–	–
Parthenium hysterophorus	82.00	85.40	111.50	155.70	150.57	124.11	141.68	120.48	111.28	136.00	115.74	115.35	120.82±6.61
Peristrophe paniculata	–	–	–	–	–	–	–	–	–	–	–	–	–
Primula species	–	–	–	–	–	–	–	49.93	–	–	–	–	49.93*±0.00
Ruellia tuberosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Rumex dentatus	–	–	–	26.90	–	–	25.56	–	–	–	–	–	26.23±0.67
Scoparia dulcis	–	–	–	–	60.74	–	–	–	–	–	–	–	60.74*±0.00
Setaria species	–	–	–	–	–	–	–	–	–	–	–	–	–
Sida rhombifolia	–	–	35.30	22.90	–	–	–	–	51.80	101.80	–	–	52.95^{ns}±17.33
Solanum nigrum	–	54.00	–	25.40	–	–	–	–	–	–	–	–	39.70*±14.30
Sonchus oleraceus	–	–	–	–	–	–	–	–	–	–	–	–	–
Trianthema portulacastrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Vernonia cinerea	–	–	–	–	–	–	–	–	–	–	–	–	–
Unidentified Acanthaceae	–	–	25.10	–	–	103.83	–	–	–	–	–	–	64.47^{ns}±39.37

Table 8. Abundance of component species at Site 2 invaded by *Ruellia tuberosa* (presented as Figure 5A).

Plant species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Mean±SD
Abutilon indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Acalypha indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Achyranthes aspera	1.00	1.00	1.30	1.00	1.00	1.67	1.25	2.00	1.50	–	–	–	1.30*±0.34
Aerva species	–	–	–	–	–	–	–	1.00	–	–	–	–	1.00±0.00
Ageratum conyzoides	–	–	–	–	–	–	–	–	–	–	–	–	–
Allernanthera pungenus	–	–	–	–	–	–	–	–	–	–	–	–	–
Amaranthus viridis	–	–	–	–	–	–	–	–	–	–	–	–	–
Argemone mexicana	–	–	–	–	–	–	–	–	–	–	–	–	–
Bidens pilosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Brachiaria ramosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Capparis sepiaria	1.25	1.75	2.00	2.75	2.00	1.50	1.25	1.50	2.00	1.20	–	–	1.72±0.46
Cenchrus ciliaris	–	–	–	–	–	–	–	–	–	–	–	–	–
Chenopodium album	–	–	–	–	–	–	–	–	–	–	–	–	–
Dichanthium annulatum	–	–	–	–	–	–	–	–	–	–	–	–	–
Eclipta prostrata	–	–	–	–	–	–	–	–	–	–	–	–	–
Erigeron bonariensis	–	–	–	–	–	–	–	–	–	–	–	–	–
Euphorbia hirta	–	–	–	–	–	–	–	–	–	–	–	–	–
Malvastrum coromandelianum	1.50	1.75	1.00	1.67	1.30	1.67	1.00	3.50	2.50	–	–	–	1.77*±0.75
Mirabilis jalapa	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxalis corniculata	–	–	–	–	–	–	–	–	–	–	–	–	–
Parthenium hysterophorus	–	–	–	–	–	–	–	–	–	–	–	–	–
Peristrophe paniculata	–	–	–	–	–	–	1.00	1.00	2.00	–	–	–	1.33*±0.47
Primula species	–	–	–	–	–	–	–	–	–	–	–	–	–
Ruellia tuberosa	**3.20**	**3.60**	**3.40**	**4.00**	**3.80**	**2.20**	**2.20**	**2.00**	**1.80**	**1.60**	–	–	**2.78±0.86**
Rumex dentatus	–	–	–	–	–	–	–	–	–	–	–	–	–
Scoparia dulcis	–	–	–	–	–	–	–	–	–	–	–	–	–
Setaria species	–	–	–	–	–	–	–	–	–	–	–	–	–
Sida rhombifolia	–	–	–	–	–	–	–	–	–	–	–	–	–
Solanum nigrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Sonchus oleraceus	–	–	–	–	–	–	–	–	–	–	–	–	–
Trianthema portulacastrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Vernonia cinerea	–	–	–	–	–	–	–	–	–	–	–	–	–
Unidentified Acanthaceae	1.00	1.50	1.30	2.00	1.50	1.50	1.67	–	–	–	–	–	1.50*±0.29

Table 9. Relative frequency of component species at Site 2 invaded by *Ruellia tuberosa* (presented as Figure 5B).

Plant species	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Mean±SD**
Abutilon indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Acalypha indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Achyranthes aspera	20.00	20.00	60.00	40.00	40.00	60.00	80.00	60.00	20.00	–	–	–	44.44^{ns}±20.61
Aerva species	–	–	–	–	–	–	–	20.00	–	–	–	–	20.00±0.00
Ageratum conyzoides	–	–	–	–	–	–	–	–	–	–	–	–	–
Allernanthera pungenus	–	–	–	–	–	–	–	–	–	–	–	–	–
Amaranthus viridis	–	–	–	–	–	–	–	–	–	–	–	–	–
Argemone mexicana	–	–	–	–	–	–	–	–	–	–	–	–	–
Bidens pilosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Brachiaria ramosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Capparis sepiaria	80.00	80.00	80.00	80.00	100.00	80.00	80.00	40.00	60.00	100.00	–	–	78.00±16.61
Cenchrus ciliaris	–	–	–	–	–	–	–	–	–	–	–	–	–
Chenopodium album	–	–	–	–	–	–	–	–	–	–	–	–	–
Dichanthium annulatum	–	–	–	–	–	–	–	–	–	–	–	–	–
Eclipta prostrata	–	–	–	–	–	–	–	–	–	–	–	–	–
Erigeron bonariensis	–	–	–	–	–	–	–	–	–	–	–	–	–
Euphorbia hirta	–	–	–	–	–	–	–	–	–	–	–	–	–
Malvastrum coromandelianum	40.00	80.00	60.00	60.00	60.00	60.00	40.00	40.00	40.00	–	–	–	53.33*±13.33
Mirabilis jalapa	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxalis corniculata	–	–	–	–	–	–	–	–	–	–	–	–	–
Parthenium hysterophorus	–	–	–	–	–	–	–	–	–	–	–	–	–
Peristrophe paniculata	–	–	–	–	–	–	20.00	20.00	20.00	–	–	–	20.00±0.00
Primula species	–	–	–	–	–	–	–	–	–	–	–	–	–
Ruellia tuberosa	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	–	–	**100.00±0.00**
Rumex dentatus	–	–	–	–	–	–	–	–	–	–	–	–	–
Scoparia dulcis	–	–	–	–	–	–	–	–	–	–	–	–	–
Setaria species	–	–	–	–	–	–	–	–	–	–	–	–	–
Sida rhombifolia	–	–	–	–	–	–	–	–	–	–	–	–	–
Solanum nigrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Sonchus oleraceus	–	–	–	–	–	–	–	–	–	–	–	–	–
Trianthema portulacastrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Vernonia cinerea	–	–	–	–	–	–	–	–	–	–	–	–	–
Unidentified Acanthaceae	20.00	40.00	60.00	40.00	40.00	40.00	60.00	–	–	–	–	–	42.86^{ns}±12.78

Table 10. Relative density of component species at Site 2 invaded by *Ruellia tuberosa* (presented as Figure 5C).

Plant species	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Mean±SD**
Abutilon indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Acalypha indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Achyranthes aspera	3.85	2.78	10.81	4.76	8.10	16.67	16.67	22.20	12.00	–	–	–	10.87^{ns}±6.30
Aerva species	–	–	–	–	–	–	–	3.80	–	–	–	–	3.80^{ns}±0.00
Ageratum conyzoides	–	–	–	–	–	–	–	–	–	–	–	–	–
Allernanthera pungenus	–	–	–	–	–	–	–	–	–	–	–	–	–
Amaranthus viridis	–	–	–	–	–	–	–	–	–	–	–	–	–
Argemone mexicana	–	–	–	–	–	–	–	–	–	–	–	–	–
Bidens pilosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Brachiaria ramosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Capparis sepiaria	19.23	19.44	21.62	26.20	22.22	20.00	16.67	11.10	24.00	42.86	–	–	22.33±7.88
Cenchrus ciliaris	–	–	–	–	–	–	–	–	–	–	–	–	–
Chenopodium album	–	–	–	–	–	–	–	–	–	–	–	–	–
Dichanthium annulatum	–	–	–	–	–	–	–	–	–	–	–	–	–
Eclipta prostrata	–	–	–	–	–	–	–	–	–	–	–	–	–
Erigeron bonariensis	–	–	–	–	–	–	–	–	–	–	–	–	–
Euphorbia hirta	–	–	–	–	–	–	–	–	–	–	–	–	–
Malvastrum coromandelianum	11.54	19.44	10.81	11.90	11.11	16.67	6.67	25.90	20.00	–	–	–	14.89^{ns}±5.68
Mirabilis jalapa	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxalis corniculata	–	–	–	–	–	–	–	–	–	–	–	–	–
Parthenium hysterophorus	–	–	–	–	–	–	–	–	–	–	–	–	–
Peristrophe paniculata	–	–	–	–	–	–	3.33	3.70	8.00	–	–	–	5.01*±2.12
Primula species	–	–	–	–	–	–	–	–	–	–	–	–	–
Ruellia tuberosa	**61.54**	**50.00**	**45.95**	**47.60**	**51.35**	**36.67**	**36.67**	**33.30**	**36.00**	**57.14**	–	–	**45.62±9.20**
Rumex dentatus	–	–	–	–	–	–	–	–	–	–	–	–	–
Scoparia dulcis	–	–	–	–	–	–	–	–	–	–	–	–	–
Setaria species	–	–	–	–	–	–	–	–	–	–	–	–	–
Sida rhombifolia	–	–	–	–	–	–	–	–	–	–	–	–	–
Solanum nigrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Sonchus oleraceus	–	–	–	–	–	–	–	–	–	–	–	–	–
Trianthema portulacastrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Vernonia cinerea	–	–	–	–	–	–	–	–	–	–	–	–	–
Unidentified Acanthaceae	3.85	8.33	10.81	9.52	8.33	10.00	16.67	–	–	–	–	–	9.64^{ns}±3.54

Table 11. Relative dominance of component species at Site 2 invaded by *Ruellia tuberosa* (presented as Figure 5D).

Plant species	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Mean±SD**
Abutilon indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Acalypha indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Achyranthes aspera	1.44	32.50	26.85	10.35	37.67	24.11	27.75	15.28	12.82	–	–	–	20.97^{ns}±11.03
Aerva species	–	–	–	–	–	–	–	2.30	–	–	–	–	2.30^{ns}±0.00
Ageratum conyzoides	–	–	–	–	–	–	–	–	–	–	–	–	–
Allernanthera pungenus	–	–	–	–	–	–	–	–	–	–	–	–	–
Amaranthus viridis	–	–	–	–	–	–	–	–	–	–	–	–	–
Argemone mexicana	–	–	–	–	–	–	–	–	–	–	–	–	–
Bidens pilosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Brachiaria ramosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Capparis sepiaria	48.47	28.03	23.83	9.32	25.62	17.77	11.81	10.50	30.77	56.76	–	–	26.29±15.06
Cenchrus ciliaris	–	–	–	–	–	–	–	–	–	–	–	–	–
Chenopodium album	–	–	–	–	–	–	–	–	–	–	–	–	–
Dichanthium annulatum	–	–	–	–	–	–	–	–	–	–	–	–	–
Eclipta prostrata	–	–	–	–	–	–	–	–	–	–	–	–	–
Erigeron bonariensis	–	–	–	–	–	–	–	–	–	–	–	–	–
Euphorbia hirta	–	–	–	–	–	–	–	–	–	–	–	–	–
Malvastrum coromandelianum	12.21	19.50	13.42	10.56	10.27	17.73	6.32	8.25	10.92	–	–	–	12.13*±3.99
Mirabilis jalapa	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxalis corniculata	–	–	–	–	–	–	–	–	–	–	–	–	–
Parthenium hysterophorus	–	–	–	–	–	–	–	–	–	–	–	–	–
Peristrophe paniculata	–	–	–	–	–	–	1.92	1.18	5.13	–	–	–	2.74^{ns}±1.71
Primula species	–	–	–	–	–	–	–	–	–	–	–	–	–
Ruellia tuberosa	**32.32**	**9.75**	**14.09**	**53.21**	**22.74**	**38.65**	**40.11**	**66.74**	**39.74**	**43.24**	–	–	**36.06±16.40**
Rumex dentatus	–	–	–	–	–	–	–	–	–	–	–	–	–
Scoparia dulcis	–	–	–	–	–	–	–	–	–	–	–	–	–
Setaria species	–	–	–	–	–	–	–	–	–	–	–	–	–
Sida rhombifolia	–	–	–	–	–	–	–	–	–	–	–	–	–
Solanum nigrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Sonchus oleraceus	–	–	–	–	–	–	–	–	–	–	–	–	–
Trianthema portulacastrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Vernonia cinerea	–	–	–	–	–	–	–	–	–	–	–	–	–
Unidentified Acanthaceae	5.39	10.38	21.81	16.56	3.43	2.13	12.09	–	–	–	–	–	10.26^{ns}±6.69

Table 12. Important value index of component species at Site 2 invaded by *Ruellia tuberosa* (presented as Figure 5E).

Plant species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Mean±SD
Abutilon indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Acalypha indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Achyranthes aspera	25.29	55.28	97.66	55.11	85.77	120.78	124.42	97.42	44.82	–	–	–	78.51^{ns}±32.87
Aerva species	–	–	–	–	–	–	–	23.78	–	–	–	–	23.78*±0.00
Ageratum conyzoides	–	–	–	–	–	–	–	–	–	–	–	–	–
Allernanthera pungenus	–	–	–	–	–	–	–	–	–	–	–	–	–
Amaranthus viridis	–	–	–	–	–	–	–	–	–	–	–	–	–
Argemone mexicana	–	–	–	–	–	–	–	–	–	–	–	–	–
Bidens pilosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Brachiaria ramosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Capparis sepiaria	147.70	127.47	125.45	115.52	127.84	114.03	108.48	101.60	124.77	199.62	–	–	129.25±26 36
Cenchrus ciliaris	–	–	–	–	–	–	–	–	–	–	–	–	–
Chenopodium album	–	–	–	–	–	–	–	–	–	–	–	–	–
Dichanthium annulatum	–	–	–	–	–	–	–	–	–	–	–	–	–
Eclipta prostrata	–	–	–	–	–	–	–	–	–	–	–	–	–
Erigeron bonariensis	–	–	–	–	–	–	–	–	–	–	–	–	–
Euphorbia hirta	–	–	–	–	–	–	–	–	–	–	–	–	–
Malvastrum coromandelianum	63.75	118.94	84.23	82.46	81.38	64.40	52.99	74.15	70.92	–	–	–	77.02*±17 69
Mirabilis jalapa	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxalis corniculata	–	–	–	–	–	–	–	–	–	–	–	–	–
Parthenium hysterophorus	–	–	–	–	–	–	–	–	–	–	–	–	–
Peristrophe paniculata	–	–	–	–	–	–	25.25	27.88	33.13	–	–	–	28.75*±3.28
Primula species	–	–	–	–	–	–	–	–	–	–	–	–	–
Ruellia tuberosa	**193.86**	**159.75**	**160.04**	**200.81**	**174.09**	**178.65**	**176.78**	**160.04**	**175.74**	**200.38**	–	–	**178.01±15.08**
Rumex dentatus	–	–	–	–	–	–	–	–	–	–	–	–	–
Scoparia dulcis	–	–	–	–	–	–	–	–	–	–	–	–	–
Setaria species	–	–	–	–	–	–	–	–	–	–	–	–	–
Sida rhombifolia	–	–	–	–	–	–	–	–	–	–	–	–	–
Solanum nigrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Sonchus oleraceus	–	–	–	–	–	–	–	–	–	–	–	–	–
Trianthema portulacastrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Vernonia cinerea	–	–	–	–	–	–	–	–	–	–	–	–	–
Unidentified Acanthaceae	29 24	58 71	92 62	66 08	51 76	52 13	88 76	–	–	–	–	–	62 76^{ns}±20 54

Table 13. Abundance of component species at Site 3 invaded by *Ruellia tuberosa* (presented as Figure 6A).

Plant species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Mean±SD
Abutilon indica	–	1.00	1.00	1.00	1.00	–	–	–	1.00	1.00	1.00	–	1.00±0.00
Acalypha indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Achyranthes aspera	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	–	1.00*±0.00
Aerva species	–	–	–	–	–	–	–	–	–	–	–	–	–
Ageratum conyzoides	–	–	–	–	–	–	–	–	2.00	1.00	1.00	–	1.33*±0.47
Allernanthera pungenus	–	–	–	–	–	–	–	–	–	–	–	–	–
Amaranthus viridis	–	–	–	–	–	–	–	–	–	–	–	–	–
Argemone mexicana	–	–	–	–	–	–	–	–	–	–	–	–	–
Bidens pilosa	1.50	2.00	3.00	2.00	1.50	2.00	1.50	1.50	1.50	1.00	1.50	–	1.73±0.49
Brachiaria ramosa	–	–	–	–	–	–	1.00	2.00	–	–	–	–	1.50*±0.50
Capparis sepiaria	–	–	–	–	–	–	–	–	–	–	–	–	–
Cenchrus ciliaris	–	1.00	3.00	1.00	2.00	1.00	–	–	2.00	1.00	–	–	1.57^{ns}±0.73
Chenopodium album	–	–	–	–	–	–	–	–	–	–	–	–	–
Dichanthium annulatum	–	–	–	–	1.00	1.00	1.00	1.00	1.00	1.00	–	–	1.00±0.00
Eclipta prostrata	1.00	1.00	1.00	1.00	2.00	–	–	–	1.00	1.50	1.00	–	1.19*±0.35
Erigeron bonariensis	–	–	–	–	–	–	–	–	–	–	–	–	–
Euphorbia hirta	–	–	–	–	–	–	–	–	–	–	–	–	–
Malvastrum coromandelianum	1.00	2.00	1.70	1.70	1.00	1.00	–	–	1.00	2.00	1.00	–	1.38*±0.43
Mirabilis jalapa	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxalis corniculata	–	–	–	2.00	–	–	–	–	–	2.00	1.50	–	1.83*±0.24
Parthenium hysterophorus	–	–	–	–	–	–	–	–	–	–	–	–	–
Peristrophe paniculata	1.00	1.00	–	–	–	–	–	–	–	–	–	–	1.00*±0.00
Primula species	–	–	–	–	–	1.00	–	–	–	1.00	–	–	1.00^{ns}±0.00
Ruellia tuberosa	**3.20**	**4.00**	**3.60**	**3.20**	**3.20**	**3.00**	**2.80**	**2.80**	**2.40**	**2.40**	**2.20**	–	**2.98±0.51**
Rumex dentatus	–	–	–	–	–	–	–	–	–	–	–	–	–
Scoparia dulcis	–	–	–	–	–	–	–	–	–	–	–	–	–
Setaria species	–	1.00	2.00	–	–	–	–	–	–	–	–	–	1.50^{ns}±0.50
Sida rhombifolia	–	–	–	–	–	–	1.00	1.00	–	–	–	–	1.00±0.00
Solanum nigrum	–	–	–	–	–	–	–	–	–	–	1.00	–	1.00^{ns}±0.00
Sonchus oleraceus	–	–	–	–	–	–	–	–	–	–	–	–	–
Trianthema portulacastrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Vernonia cinerea	–	–	–	–	–	2.00	–	–	1.00	1.00	–	–	1.33*±0.47
Unidentified Acanthaceae	1.00	1.50	1.00	2.00	3.00	2.00	1.80	1.50	1.00	1.00	1.00	–	1.53*±0.61

Table 14. Relateive frequency of component species at Site 3 invaded by *Ruellia tuberosa* (presented as Figure 6B).

Plant species	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Mean±SD**
Abutilon indica	–	20.00	20.00	20.00	20.00	–	–	–	20.00	20.00	20.00	–	20.00±0.00
Acalypha indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Achyranthes aspera	20.00	20.00	20.00	40.00	20.00	40.00	20.00	60.00	20.00	20.00	20.00	–	27.27*±12.86
Aerva species	–	–	–	–	–	–	–	–	–	–	–	–	–
Ageratum conyzoides	–	–	–	–	–	–	–	–	20.00	40.00	40.00	–	33.33^{ns}±9.43
Allernanthera pungenus	–	–	–	–	–	–	–	–	–	–	–	–	–
Amaranthus viridis	–	–	–	–	–	–	–	–	–	–	–	–	–
Argemone mexicana	–	–	–	–	–	–	–	–	–	–	–	–	–
Bidens pilosa	40.00	20.00	20.00	20.00	40.00	20.00	40.00	40.00	40.00	40.00	40.00	–	32.73±9.62
Brachiaria ramosa	–	–	–	–	–	–	20.00	60.00	–	–	–	–	40.00±20.00
Capparis sepiaria	–	–	–	–	–	–	–	–	–	–	–	–	–
Cenchrus ciliaris	–	20.00	20.00	20.00	20.00	20.00	–	–	20.00	20.00	–	–	20.00*±0.00
Chenopodium album	–	–	–	–	–	–	–	–	–	–	–	–	–
Dichanthium annulatum	–	–	–	–	20.00	20.00	20.00	20.00	20.00	20.00	–	–	20.00±0.00
Eclipta prostrata	40.00	20.00	20.00	40.00	40.00	–	–	–	40.00	40.00	40.00	–	35.00^{ns}±8.66
Erigeron bonariensis	–	–	–	–	–	–	–	–	–	–	–	–	–
Euphorbia hirta	–	–	–	–	–	–	–	–	–	–	–	–	–
Malvastrum coromandelianum	20.00	20.00	20.00	60.00	20.00	40.00	–	–	40.00	20.00	40.00	–	31.11^{ns}±13.70
Mirabilis jalapa	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxalis corniculata	–	–	–	20.00	–	–	–	–	–	20.00	40.00	–	26.67*±9.43
Parthenium hysterophorus	–	–	–	–	–	–	–	–	–	–	–	–	–
Peristrophe paniculata	20.00	20.00	–	–	–	–	–	–	–	–	–	–	20.00±0.00
Primula species	–	–	–	–	–	20.00	–	–	–	20.00	–	–	20.00±0.00
Ruellia tuberosa	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	–	**100.00±0.00**
Rumex dentatus	–	–	–	–	–	–	–	–	–	–	–	–	–
Scoparia dulcis	–	–	–	–	–	–	–	–	–	–	–	–	–
Setaria species	–	20.00	20.00	–	–	–	–	–	–	–	–	–	20.00±0.00
Sida rhombifolia	–	–	–	–	–	–	20.00	40.00	–	–	–	–	30.00^{ns}±10.00
Solanum nigrum	–	–	–	–	–	–	–	–	–	–	20.00	–	20.00*±0.00
Sonchus oleraceus	–	–	–	–	–	–	–	–	–	–	–	–	–
Trianthema portulacastrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Vernonia cinerea	–	–	–	–	–	20.00	–	–	20.00	40.00	–	–	26.67*±9.43
Unidentified Acanthaceae	–	20.00	20.00	20.00	20.00	20.00	80.00	40.00	20.00	20.00	20.00	–	28.00^{ns}±18.33

Table 15. Relative density of component species at Site 3 invaded by *Ruellia tuberosa* (presented as Figure 6C).

Plant species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Mean±SD
Abutilon indica	–	3.03	3.23	3.13	3.13	–	–	–	3.70	3.33	3.57	–	$3.30^{ns}\pm0.23$
Acalypha indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Achyranthes aspera	3.70	3.03	3.13	6.25	3.13	6.90	3.57	3.33	3.70	3.33	7.14	–	$4.29^{ns}\pm1.54$
Aerva species	–	–	–	–	–	–	–	–	–	–	–	–	–
Ageratum conyzoides	–	–	–	–	–	–	–	–	3.70	6.67	7.14	–	$5.84^{ns}\pm1.52$
Allernanthera pungenus	–	–	–	–	–	–	–	–	–	–	–	–	–
Amaranthus viridis	–	–	–	–	–	–	–	–	–	–	–	–	–
Argemone mexicana	–	–	–	–	–	–	–	–	–	–	–	–	–
Bidens pilosa	11.11	6.06	9.38	6.25	9.38	6.90	10.71	13.33	11.11	6.67	10.71	–	9.24±2.32
Brachiaria ramosa	–	–	–	–	–	–	3.57	13.33	–	–	–	–	$8.45^{ns}\pm4.88$
Capparis sepiaria	–	–	–	–	–	–	–	–	–	–	–	–	–
Cenchrus ciliaris	–	3.03	9.38	3.13	6.25	6.90	–	–	3.70	3.33	–	–	$5.10^{ns}\pm2.27$
Chenopodium album	–	–	–	–	–	–	–	–	–	–	–	–	–
Dichanthium annulatum	–	–	–	–	3.13	3.45	3.57	3.03	3.70	3.33	–	–	3.37±0.10
Eclipta prostrata	7.40	3.03	3.13	3.13	3.13	–	–	–	7.40	6.67	7.14	–	$5.13^{ns}\pm2.03$
Erigeron bonariensis	–	–	–	–	–	–	–	–	–	–	–	–	–
Euphorbia hirta	–	–	–	–	–	–	–	–	–	–	–	–	–
Malvastrum coromandelianum	3.70	6.06	3.13	15.63	12.50	6.90	–	–	7.40	6.67	7.24	–	$7.69^{ns}\pm3.76$
Mirabilis jalapa	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxalis corniculata	–	–	–	6.25	–	–	–	–	–	6.67	10.71	–	$7.88^{ns}\pm2.01$
Parthenium hysterophorus	–	–	–	–	–	–	–	–	–	–	–	–	–
Peristrophe paniculata	3.70	3.03	–	–	–	–	–	–	–	–	–	–	$3.37^{ns}\pm0.33$
Primula species	–	–	–	–	–	3.45	–	–	–	3.33	–	–	$3.39^{ns}\pm0.06$
Ruellia tuberosa	**59.26**	**60.60**	**56.25**	**50.00**	**50.00**	**51.72**	**50.00**	**46.67**	**44.44**	**40.00**	**39.29**	–	**49.84±6.72**
Rumex dentatus	–	–	–	–	–	–	–	–	–	–	–	–	–
Scoparia dulcis	–	–	–	–	–	–	–	–	–	–	–	–	–
Setaria species	–	3.03	6.25	–	–	–	–	–	–	–	–	–	4.64*±1.61
Sida rhombifolia	–	–	–	–	–	–	3.57	6.67	–	–	–	–	5.12*±1.55
Solanum nigrum	–	–	–	–	–	–	–	–	–	–	3.57	–	$3.57^{ns}\pm0.00$
Sonchus oleraceus	–	–	–	–	–	–	–	–	–	–	–	–	–
Trianthema portulacastrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Vernonia cinerea	–	–	–	–	–	6.90	–	–	3.70	6.67	–	–	$5.76^{ns}\pm1.46$
Unidentified Acanthaceae	11.11	9.09	6.25	6.25	9.38	6.90	25.00	16.67	7.40	3.33	3.57	–	$9.54^{ns}\pm6.03$

Table 16. Relative dominance of component species at Site 3 invaded by *Ruellia tuberosa* (presented as Figure 6D).

Plant species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Mean±SD
Abutilon indica	–	11.15	3.33	7.01	2.80	–	–	–	7.29	8.50	13.09	–	$7.60^{*}\pm3.49$
Acalypha indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Achyranthes aspera	14.85	7.96	22.17	20.02	6.54	9.85	7.20	63.29	13.54	15.78	23.56	–	$18.61^{ns}\pm15.22$
Aerva species	–	–	–	–	–	–	–	–	–	–	–	–	–
Ageratum conyzoides	–	–	–	–	–	–	–	–	8.33	7.28	10.47	–	$8.69^{*}\pm1.33$
Allernanthera pungenus	–	–	–	–	–	–	–	–	–	–	–	–	–
Amaranthus viridis	–	–	–	–	–	–	–	–	–	–	–	–	–
Argemone mexicana	–	–	–	–	–	–	–	–	–	–	–	–	–
Bidens pilosa	42.08	1.91	2.44	1.20	8.41	9.85	2.26	4.43	4.17	2.43	1.83	–	7.36 ± 11.30
Brachiaria ramosa	–	–	–	–	–	–	1.03	2.03	–	–	–	–	$1.53^{ns}\pm0.50$
Capparis sepiaria	–	–	–	–	–	–	–	–	–	–	–	–	–
Cenchrus ciliaris	–	4.78	14.41	5.01	11.21	4.93	–	–	13.54	8.50	–	–	$8.91^{ns}\pm3.88$
Chenopodium album	–	–	–	–	–	–	–	–	–	–	–	–	–
Dichanthium annulatum	–	–	–	–	2.80	2.46	1.03	1.90	2.08	3.64	–	–	2.32 ± 0.81
Eclipta prostrata	2.97	4.78	3.33	3.00	6.54	–	–	–	7.29	4.85	5.23	–	$4.75^{ns}\pm1.51$
Erigeron bonariensis	–	–	–	–	–	–	–	–	–	–	–	–	–
Euphorbia hirta	–	–	–	–	–	–	–	–	–	–	–	–	–
Malvastrum coromandelianum	2.48	6.37	1.11	25.03	8.41	6.16	–	–	2.08	4.85	1.57	–	$6.45^{ns}\pm6.98$
Mirabilis jalapa	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxalis corniculata	–	–	–	3.00	–	–	–	–	–	0.49	1.05	–	$1.51^{ns}\pm1.08$
Parthenium hysterophorus	–	–	–	–	–	–	–	–	–	–	–	–	–
Peristrophe paniculata	2.48	4.78	–	–	–	–	–	–	–	–	–	–	$3.63^{ns}\pm1.15$
Primula species	–	–	–	–	–	2.46	–	–	–	1.21	–	–	$1.84^{ns}\pm0.63$
Ruellia tuberosa	**5.45**	**24.80**	**33.26**	**28.43**	**28.04**	**35.71**	**29.84**	**15.19**	**23.96**	**24.27**	**30.10**	–	$\mathbf{25.37\pm8.16}$
Rumex dentatus	–	–	–	–	–	–	–	–	–	–	–	–	–
Scoparia dulcis	–	–	–	–	–	–	–	–	–	–	–	–	–
Setaria species	–	1.59	2.22	–	–	–	–	–	–	–	–	–	$1.91^{ns}\pm0.32$
Sida rhombifolia	–	–	–	–	–	–	7.20	8.86	–	–	–	–	$8.03^{*}\pm0.83$
Solanum nigrum	–	–	–	–	–	–	–	–	–	–	3.93	–	$3.93^{ns}\pm0.00$
Sonchus oleraceus	–	–	–	–	–	–	–	–	–	–	–	–	–
Trianthema portulacastrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Vernonia cinerea	–	–	–	–	–	2.46	–	–	1.04	2.43	–	–	$1.98^{ns}\pm0.66$
Unidentified Acanthaceae	29.70	36.62	17.74	10.01	25.23	28.33	51.44	4.43	13.54	15.78	9.16	–	$22.00^{ns}\pm13.27$

Table 17. Important value index of component species at Site 3 invaded by *Ruellia tuberosa* (presented as Figure 6E).

Plant species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Mean±SD
Abutilon indica	–	34.18	26.46	30.14	25.93	–	–	–	30.93	31.83	36.66	–	30.88*±3.58
Acalypha indica	–	–	–	–	–	–	–	–	–	–	–	–	–
Achyranthes aspera	38.55	30.99	45.30	66.27	29.67	56.75	40.77	133.29	37.24	39.11	50.70	–	51.69*±27.82
Aerva species	–	–	–	–	–	–	–	–	–	–	–	–	–
Ageratum conyzoides	–	–	–	–	–	–	–	–	35.73	53.95	57.61	–	49.10*±9.57
Allernanthera pungenus	–	–	–	–	–	–	–	–	–	–	–	–	–
Amaranthus viridis	–	–	–	–	–	–	–	–	–	–	–	–	–
Argemone mexicana	–	–	–	–	–	–	–	–	–	–	–	–	–
Bidens pilosa	93.19	27.97	31.82	27.45	57.79	36.75	52.97	57.76	55.28	49.70	52.54	–	49.38±17.90
Brachiaria ramosa	–	–	–	–	–	–	24.60	75.36	–	–	–	–	49.98*±25.38
Capparis sepiaria	–	–	–	–	–	–	–	–	–	–	–	–	–
Cenchrus ciliaris	–	27.81	25.79	28.14	37.46	31.83	–	–	27.24	31.83	–	–	30.01^{ns}±3.70
Chenopodium album	–	–	–	–	–	–	–	–	–	–	–	–	–
Dichanthium annulatum	–	–	–	–	25.93	25.91	24.60	24.93	25.78	26.97	–	–	25.69±0.34
Eclipta prostrata	50.37	27.81	26.46	46.13	60.91	60.91	–	–	54.69	51.52	52.97	–	47.97^{ns}±4.24
Erigeron bonariensis	–	–	–	–	–	–	–	–	–	–	–	–	–
Euphorbia hirta	–	–	–	–	–	–	–	–	–	–	–	–	–
Malvastrum coromandelianum	26.18	32.43	24.24	100.66	29.67	53.06	–	–	49.48	31.52	43.71	–	43.44^{ns}±22.42
Mirabilis jalapa	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxalis corniculata	–	–	–	29.25	–	–	–	–	–	27.16	51.76	–	36.06^{ns}±11.14
Parthenium hysterophorus	–	–	–	–	–	–	–	–	–	–	–	–	–
Peristrophe paniculata	26.18	27.80	–	–	–	–	–	–	–	–	–	–	26.99*±0.81
Primula species	–	–	–	–	–	25.91	–	–	–	24.54	–	–	25.23^{ns}±0.68
Ruellia tuberosa	**164.71**	**185.40**	**189.51**	**178.43**	**178.04**	**187.43**	**179.84**	**161.86**	**168.40**	**164.27**	**69.39**	–	**166.12±31.97**
Rumex dentatus	–	–	–	–	–	–	–	–	–	–	–	–	–
Scoparia dulcis	–	–	–	–	–	–	–	–	–	–	–	–	–
Setaria species	–	24.62	28.47	–	–	–	–	–	–	–	–	–	26.55*±1.92
Sida rhombifolia	–	–	–	–	–	–	30.77	55.53	–	–	–	–	43.15*±12.38
Solanum nigrum	–	–	–	–	–	–	–	–	–	–	27.50	–	27.50^{ns}±0.00
Sonchus oleraceus	–	–	–	–	–	–	–	–	–	–	–	–	–
Trianthema portulacastrum	–	–	–	–	–	–	–	–	–	–	–	–	–
Vernonia cinerea	–	–	–	–	–	29.38	–	–	24.74	49.10	–	–	34.41*±10.56
Unidentified Acanthaceae	100.81	85.71	43.99	36.26	54.61	55.23	156.44	61.10	40.94	39.11	32.73	–	64.27^{ns}±11.22

Table 18. Abundance of component species at Site 4 non-invaded community patch (presented as Figure 7A).

Plant species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean±SD
Abutilon indica	1.00	–	–	–	–	–	–	–	–	1.00	1.00	1.00	1.00±0.00
Acalypha indica	1.00	1.00	–	–	–	1.00	1.00	1.50	–	–	–	1.50	1.17±0.24
Achyranthes aspera	1.00	1.00	1.00	1.00	1.00	1.00	–	–	–	2.00	1.00	2.00	1.22±0.42
Aerva species	–	–	–	–	–	–	–	–	–	–	1.00	–	1.00±0.00
Ageratum conyzoides	2.00	1.00	1.00	1.00	1.00	2.00	1.00	–	–	–	–	–	1.29±0.45
Allernanthera pungenus	–	–	–	–	–	–	–	–	–	–	–	–	–
Amaranthus viridis	–	–	–	–	1.00	1.50	1.50	1.33	1.20	2.00	2.00	1.33	1.48±0.33
Argemone mexicana	–	–	–	2.00	–	–	–	–	–	–	–	–	2.00±0.00
Bidens pilosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Brachiaria ramosa	–	–	–	–	–	–	–	–	–	1.50	1.00	–	1.25±0.25
Capparis sepiaria	–	–	–	–	–	–	–	–	–	–	–	–	–
Cenchrus ciliaris	1.50	1.00	–	–	–	1.00	1.00	–	–	–	–	1.00	1.10±0.20
Chenopodium album	–	–	1.50	1.00	–	–	–	–	–	–	–	–	1.25±0.25
Dichanthium annulatum	–	–	–	–	–	–	–	–	–	–	–	–	–
Eclipta prostrata	1.00	1.00	–	–	2.00	–	–	–	2.00	1.00	1.00	–	1.33±0.47
Erigeron bonariensis	–	–	–	–	2.00	1.00	2.00	2.00	–	–	–	–	1.75±0.43
Euphorbia hirta	–	–	–	–	–	1.50	1.00	–	–	–	2.00	1.50	1.50±0.35
Malvastrum coromandelianum	2.00	1.67	1.50	1.33	1.67	1.50	1.30	1.67	1.67	1.67	1.00	1.00	1.50±0.28
Mirabilis jalapa	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxalis corniculata	–	2.00	–	–	–	–	–	–	–	–	–	–	2.00±0.00
Parthenium hysterophorus	–	–	–	–	–	–	–	–	–	–	–	–	–
Peristrophe paniculata	–	–	–	2.00	1.00	–	–	–	–	1.00	1.00	–	1.25±0.43
Primula species	2.00	–	–	–	–	–	–	–	–	–	–	–	2.00±0.00
Ruellia tuberosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Rumex dentatus	–	–	–	–	–	–	–	–	–	–	–	–	–
Scoparia dulcis	–	–	2.00	2.00	2.00	1.00	–	–	–	–	–	–	1.75±0.43
Setaria species	–	1.00	–	–	–	–	–	–	–	–	–	–	1.00±0.00
Sida rhombifolia	–	–	–	–	–	–	–	–	–	–	1.00	–	1.00±0.00
Solanum nigrum	2.00	1.33	2.00	2.00	1.00	1.00	2.00	–	–	–	–	–	1.62±0.45
Sonchus oleraceus	–	–	–	–	–	–	1.00	2.00	2.00	2.00	–	–	1.75±0.43
Trianthema portulacastrum	–	–	2.00	1.00	–	–	–	–	–	–	1.00	2.00	1.50±0.50
Vernonia cinerea	1.00	–	–	–	–	–	–	–	–	–	–	2.00	1.50±0.50
Unidentified Acanthaceae	–	–	–	1.00	2.00	1.00	1.00	–	–	–	–	–	1.25±0.43

Table 19. Relative frequency of component species at Site 4 non-invaded community patch (presented as Figure 7B).

Plant species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean±SD
Abutilon indica	20.00	–	–	–	–	–	–	–	–	20.00	20.00	20.00	20.00±0.00
Acalypha indica	20.00	20.00	–	–	–	20.00	20.00	40.00	–	–	–	40.00	26.67±9.43
Achyranthes aspera	20.00	40.00	40.00	20.00	20.00	20.00	–	–	–	20.00	20.00	20.00	24.44±8.31
Aerva species	–	–	–	–	–	–	–	–	–	–	20.00	–	20.00±0.00
Ageratum conyzoides	20.00	20.00	20.00	20.00	20.00	40.00	20.00	–	–	–	–	–	22.86±7.00
Allernanthera pungenus	–	–	–	–	–	–	–	–	–	–	–	–	–
Amaranthus viridis	–	–	–	–	20.00	40.00	40.00	60.00	100.00	40.00	20.00	60.00	47.50±24.37
Argemone mexicana	–	–	–	20.00	–	–	–	–	–	–	–	–	20.00±0.00
Bidens pilosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Brachiaria ramosa	–	–	–	–	–	–	–	–	–	40.00	40.00	–	40.00±0.00
Capparis sepiaria	–	–	–	–	–	–	–	–	–	–	–	–	–
Cenchrus ciliaris	40.00	20.00	–	–	–	20.00	20.00	–	–	–	–	20.00	24.00±8.00
Chenopodium album	–	–	40.00	40.00	–	–	–	–	–	–	–	–	40.00±0.00
Dichanthium annulatum	–	–	–	–	–	–	–	–	–	–	–	–	–
Eclipta prostrata	20.00	20.00	–	–	20.00	–	–	–	20.00	40.00	20.00	–	23.33±7.45
Erigeron bonariensis	–	–	–	–	20.00	20.00	20.00	20.00	–	–	–	–	20.00±0.00
Euphorbia hirta	–	–	–	–	–	40.00	20.00	–	–	–	20.00	40.00	30.00±10.00
Malvastrum coromandelianum	20.00	60.00	40.00	60.00	60.00	80.00	60.00	60.00	60.00	60.00	40.00	20.00	51.67±17.24
Mirabilis jalapa	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxalis corniculata	–	20.00	–	–	–	–	–	–	–	–	–	–	20.00±0.00
Parthenium hysterophorus	–	–	–	–	–	–	–	–	–	–	–	–	–
Peristrophe paniculata	–	–	–	20.00	20.00	–	–	–	–	20.00	20.00	–	20.00±0.00
Primula species	20.00	–	–	–	–	–	–	–	–	–	–	–	20.00±0.00
Ruellia tuberosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Rumex dentatus	–	–	–	–	–	–	–	–	–	–	–	–	–
Scoparia dulcis	–	–	20.00	20.00	60.00	20.00	–	–	–	–	–	–	30.00±17.32
Setaria species	–	20.00	–	–	–	–	–	–	–	–	–	–	20.00±0.00
Sida rhombifolia	–	–	–	–	–	–	–	–	–	–	20.00	–	20.00±0.00
Solanum nigrum	20.00	60.00	20.00	20.00	20.00	20.00	20.00	–	–	–	–	–	25.71±14.00
Sonchus oleraceus	–	–	–	–	–	–	20.00	20.00	20.00	20.00	–	–	20.00±0.00
Trianthema portulacastrum	–	–	20.00	20.00	–	–	–	–	–	–	20.00	20.00	20.00±0.00
Vernonia cinerea	20.00	–	–	–	–	–	–	–	–	–	–	20.00	20.00±0.00
Unidentified Acanthaceae	–	–	–	20.00	20.00	20.00	20.00	–	–	–	–	–	20.00±0.00

Table 20. Relative density of component species at Site 4 non-invaded community patch (presented as Figure 7C).

Plant species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean±SD
Abutilon indica	6.25	–	–	–	–	–	–	–	–	5.00	6.25	5.26	5.69±0.57
Acalypha indica	6.25	5.56	–	–	–	4.35	5.88	18.75	–	–	–	15.79	9.43±5.64
Achyranthes aspera	6.25	11.11	6.67	4.76	4.55	4.35	–	–	–	1.00	6.25	10.53	6.16±2.95
Aerva species	–	–	–	–	–	–	–	–	–	–	6.25	–	6.25±0.00
Ageratum conyzoides	12.50	5.55	6.67	4.76	4.55	17.39	5.88	–	–	–	–	–	8.19±4.52
Allernanthera pungenus	–	–	–	–	–	–	–	–	–	–	–	–	–
Amaranthus viridis	–	–	–	–	4.55	13.04	17.65	25.00	35.30	20.00	12.50	21.05	18.64±8.62
Argemone mexicana	–	–	–	9.52	–	–	–	–	–	–	–	–	9.52±0.00
Bidens pilosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Brachiaria ramosa	–	–	–	–	–	–	–	–	–	15.00	12.50	–	13.75±1.25
Capparis sepiaria	–	–	–	–	–	–	–	–	–	–	–	–	–
Cenchrus ciliaris	18.75	11.11	–	–	–	4.30	5.88	–	–	–	–	5.26	9.06±5.39
Chenopodium album	–	–	20.00	9.52	–	–	–	–	–	–	–	–	14.76±5.24
Dichanthium annulatum	–	–	–	–	–	–	–	–	–	–	–	–	–
Eclipta prostrata	6.25	5.56	–	–	9.09	–	–	–	11.77	10.00	6.25	–	8.15±2.29
Erigeron bonariensis	–	–	–	–	9.09	4.35	11.76	12.50	–	–	–	–	9.43±3.19
Euphorbia hirta	–	–	–	–	–	13.04	5.88	–	–	–	12.50	15.79	11.80±3.64
Malvastrum coromandelianum	12.50	27.78	20.00	19.05	22.73	26.09	23.53	31.25	29.40	25.00	12.50	5.26	21.26±7.47
Mirabilis jalapa	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxalis corniculata	–	11.11	–	–	–	–	–	–	–	–	–	–	11.11±0.00
Parthenium hysterophorus	–	–	–	–	–	–	–	–	–	–	–	–	–
Peristrophe paniculata	–	–	–	9.52	4.55	–	–	–	–	3.00	6.25	–	5.83±2.42
Primula species	12.50	–	–	–	–	–	–	–	–	–	–	–	12.50±0.00
Ruellia tuberosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Rumex dentatus	–	–	–	–	–	–	–	–	–	–	–	–	–
Scoparia dulcis	–	–	13.33	9.52	27.27	4.35	–	–	–	–	–	–	13.62±8.50
Setaria species	–	5.56	–	–	–	–	–	–	–	–	–	–	5.56±0.00
Sida rhombifolia	–	–	–	–	–	–	–	–	–	–	6.25	–	6.25±0.00
Solanum nigrum	12.50	22.22	13.33	9.52	4.55	4.35	11.76	–	–	–	–	–	11.18±5.63
Sonchus oleraceus	–	–	–	–	–	–	5.88	12.50	11.77	10.00	–	–	10.04±2.57
Trianthema portulacastrum	–	–	13.33	4.76	–	–	–	–	–	–	6.25	10.53	8.72±3.40
Vernonia cinerea	6.25	–	–	–	–	–	–	–	–	–	–	10.53	8.39±2.14
Unidentified Acanthaceae	–	–	–	4.76	9.09	4.35	5.88	–	–	–	–	–	6.02±1.86

Table 21. Relative dominance of component species at Site 4 non-invaded community patch (presented as Figure 7D).

Plant species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean±SD
Abutilon indica	17 33	–	–	–	–	–	–	–	–	5.60	6.65	6.60	9.05±4.80
Acalypha indica	7.43	2.72	–	–	–	4.63	7.14	24.77	–	–	–	5.66	8.73±7.35
Achyranthes aspera	7.43	10.87	6.45	11.49	5.07	4.64	–	–	–	1.60	3.99	7.55	6.57±3.01
Aerva species	–	–	–	–	–	–	–	–	–	–	0.27	–	0.27±0.00
Ageratum conyzoides	7 43	19.02	8.07	1 15	5.07	18.57	1.02	–	–	–	–	–	8.62±6.92
Allernanthera pungenus	–	–	–	–	–	–	–	–	–	–	–	–	–
Amaranthus viridis	–	–	–	–	11.82	21.67	33.67	34.60	81.97	41.60	43.88	50.04	39.91±19.62
Argemone mexicana	–	–	–	13 79	–	–	–	–	–	–	–	–	13.79±0.00
Bidens pilosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Brachiaria ramosa	–	–	–	–	–	–	–	–	–	13.60	7.98	–	10.79±2.81
Capparis sepiaria	–	–	–	–	–	–	–	–	–	–	–	–	–
Cenchrus ciliaris	24.75	13.59	–	–	–	7.74	13.27	–	–	–	–	9.43	13.76±5 93
Chenopodium album	–	–	12.90	2.30	–	–	–	–	–	–	–	–	7.60±5.30
Dichanthium annulatum	–	–	–	–	–	–	–	–	–	–	–	–	–
Eclipta prostrata	0.50	0.54	–	–	2.03	0.93	–	–	1.64	4.00	1.33	–	1.57±1.12
Erigeron bonariensis	–	–	–	–	16.89	1.93	4.08	12 84	–	–	–	–	8.94±6.15
Euphorbia hirta	–	–	–	–	–	10.84	3.06	–	–	–	13.30	4.72	7.98±4.22
Malvastrum coromandelianum	5 00	29.89	11.29	9.20	13 51	15 48	7.14	12.84	8.19	7.20	5.32	2.83	10.66±6.84
Mirabilis jalapa	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxalis corniculata	–	1.09	–	–	–	–	–	–	–	–	–	–	1 09±0.00
Parthenium hysterophorus	–	–	–	–	–	–	–	–	–	–	–	–	–
Peristrophe paniculata	–	–	–	11 49	5.07	–	–	–	–	2 40	13.99	–	8.24±4.68
Primula species	2.97	–	–	–	–	–	–	–	–	–	–	–	2 97±0.00
Ruellia tuberosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Rumex dentatus	–	–	–	–	–	–	–	–	–	–	–	–	–
Scoparia dulcis	–	–	16 13	9 20	33 78	1 55	–	–	–	–	–	–	15 17±11 92
Setaria species	–	0 54	–	–	–	–	–	–	–	–	–	–	0 54±0 00
Sida rhombifolia	–	–	–	–	–	–	–	–	–	–	9.31	–	9.31±0.00
Solanum nigrum	19 80	21 74	12 90	17 24	1 69	3 10	12.25	–	–	–	–	–	12 67±7 23
Sonchus oleraceus	–	–	–	–	–	–	3 06	14 68	8 20	9 60	–	–	8 89±4 14
Trianthema portulacastrum	–	–	32 26	5 75	–	–	–	–	–	–	3 99	9 43	12 86±11 37
Vernonia cinerea	7 43	–	–	–	–	–	–	–	–	–	–	3 77	5 60±1 83
Unidentified Acanthaceae	–	–	–	3 45	5 07	10 84	10 20	–	–	–	–	–	7 39±3 19

Table 22. Important value index of component species at Site 4 non-invaded community patch (presented as Figure 7E).

Plant species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean±SD
Abutilon indica	44.58	–	–	–	–	–	–	–	–	31.60	33.90	32.86	35.74±5.17
Acalypha indica	34.68	29.28	–	–	–	29.98	34.02	85.02	–	–	–	62.95	45.99±20.89
Achyranthes aspera	34.68	62.98	54.12	37.25	30.62	29.99	–	–	–	48.00	31.24	40.08	41.00±10.97
Aerva species	–	–	–	–	–	–	–	–	–	–	27.52	–	27.52±0.00
Ageratum conyzoides	41.93	45.58	35.74	26.91	30.62	77.92	27.90	–	–	–	–	–	40.94±16.43
Allernanthera pungenus	–	–	–	–	–	–	–	–	–	–	–	–	–
Amaranthus viridis	–	–	–	–	37.37	76.21	92.82	121.19	218.47	143.60	78.38	132.42	112.56±51.46
Argemone Mexicana	–	–	–	45.31	–	–	–	–	–	–	–	–	45.31±0.00
Bidens pilosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Brachiaria ramosa	–	–	–	–	–	–	–	–	–	70.10	61.48	–	65.79±4.31
Capparis sepiaria	–	–	–	–	–	–	–	–	–	–	–	–	–
Cenchrus ciliaris	85.00	45.70	–	–	–	33.09	40.15	–	–	–	–	35.69	47.93±19.02
Chenopodium album	–	–	74.40	89.28	–	–	–	–	–	–	–	–	81.84±7.44
Dichanthium annulatum	–	–	–	–	–	–	–	–	–	–	–	–	–
Eclipta prostrata	27.75	27.10	–	–	33.12	–	–	–	35.41	55.00	28.58	–	34.49±9.65
Erigeron bonariensis	–	–	–	–	47.98	26.28	37.84	47.34	–	–	–	–	39.86±8.81
Euphorbia hirta	–	–	–	–	–	65.38	29.94	–	–	–	47.80	62.01	51.28±13.98
Malvastrum coromandelianum	39.50	119.34	72.79	89.58	97.01	123.06	91.97	51.76	99.27	93.87	58.82	29.09	80.51±28.89
Mirabilis jalapa	–	–	–	–	–	–	–	–	–	–	–	–	–
Oxalis corniculata	–	3.42	–	–	–	–	–	–	–	–	–	–	3.42±0.00
Parthenium hysterophorus	–	–	–	–	–	–	–	–	–	–	–	–	–
Peristrophe paniculata	–	–	–	43.01	30.62	–	–	–	–	28.40	41.24	–	35.82±6.39
Primula species	37.47	–	–	–	–	–	–	–	–	–	–	–	37.47±0.00
Ruellia tuberosa	–	–	–	–	–	–	–	–	–	–	–	–	–
Rumex dentatus	–	–	–	–	–	–	–	–	–	–	–	–	–
Scoparia dulcis	–	–	51.46	40.72	123.05	26.90	–	–	–	–	–	–	60.53±37.13
Setaria species	–	27.10	–	–	–	–	–	–	–	–	–	–	27.10±0.00
Sida rhombifolia	–	–	–	–	–	–	–	–	–	–	36.56	–	36.56±0.00
Solanum nigrum	54.30	105.29	46.23	48.76	27.24	28.45	26.01	–	–	–	–	–	48.04±25.70
Sonchus oleraceus	–	–	–	–	–	–	29.94	49.18	41.97	41.60	–	–	40.67±6.89
Trianthema portulacastrum	–	–	67.59	31.51	–	–	–	–	–	–	31.24	41.96	43.08±14.80
Vernonia cinerea	34.68	–	–	–	–	–	–	–	–	–	–	36.30	35.49±0.81
Unidentified Acanthaceae	–	–	–	29.21	36.16	36.19	37.08	–	–	–	–	–	34.66±3.17

Table 23. Community indices at Site 1 (invaded by *Mirabilis jalapa*), Site 2, 3 (invaded by *Ruellia tuberosa*) and Site 4 (non-invaded) (presented as Figure 8 and 9).

Community Indices	Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean±SD
Margalef's Richness index (R)	1	1.38	1.28	2.10	2.47	1.15	1.41	1.65	1.16	1.49	1.46	1.19	1.28	$1.50^{*}\pm0.38$
	2	0.38	–	–	1.23	1.13	1.11	1.07	1.12	1.19	1.46	1.50	1.26	$1.15^{*}\pm0.59$
	3	3.53	2.70	–	1.82	2.7	2.31	2.30	2.29	2.38	1.80	1.76	3.00	$2.42^{ns}\pm0.89$
	4	2.89	2.77	2.22	3.34	2.91	3.19	3.18	1.44	1.06	2.67	3.61	2.42	2.64 ± 0.73
Simpson's Dominance index (λ)	1	0.25	0.26	0.28	0.25	0.35	0.26	0.27	0.26	0.23	0.23	0.25	0.26	$0.26^{*}\pm0.03$
	2	0.51	–	–	0.43	0.32	0.29	0.32	0.35	0.25	0.25	0.25	0.25	$0.32^{*}\pm0.17$
	3	0.19	0.20	–	0.39	0.29	0.25	0.29	0.30	0.30	0.33	0.27	0.22	$0.28^{*}\pm0.10$
	4	0.13	0.17	0.16	0.11	0.16	0.15	0.13	0.23	0.28	0.14	0.10	0.15	0.16 ± 0.01
Shannon's Diversity index (H)	1	1.48	1.46	1.61	1.76	1.25	1.54	1.54	1.47	1.61	1.63	1.47	1.48	$1.53^{ns}\pm0.12$
	2	0.62	–	–	1.12	1.31	1.41	1.33	1.28	1.48	1.56	1.52	1.48	$1.31^{*}\pm0.64$
	3	2.13	1.96	–	1.36	1.50	1.55	1.66	1.63	1.68	1.41	1.61	1.95	$1.68^{ns}\pm0.56$
	4	2.13	1.98	1.89	2.32	2.05	2.14	2.15	1.54	1.32	2.08	2.34	1.99	1.99 ± 0.28
Hill's Evenness Index (E)	1	0.92	0.91	0.77	0.77	0.77	0.86	0.79	0.92	0.90	0.91	0.91	0.92	$0.86^{ns}\pm0.06$
	2	0.99	–	–	0.69	0.81	0.88	0.82	0.80	0.92	0.87	0.85	0.92	$0.86^{ns}\pm0.39$
	3	0.83	0.85	–	0.70	0.65	0.70	0.75	0.74	0.77	0.72	0.83	0.81	$0.76^{ns}\pm0.24$
	4	0.97	0.90	0.98	0.97	0.89	0.89	0.93	0.90	0.95	0.95	0.98	0.96	0.94 ± 0.03

Table 24. Monthly vegetative and reproductive growth of *Mirabilis jalapa* in pots (under cultivation) and at Site 1 (in wild) (presented as Figure 10 and 13).

Months		Plant height	Leaf plant^{-1}	Leaf area	Total leaf area plant^{-1}	Floral bud plant^{-1}	Flower plant^{-1}	Fruit plant^{-1}	Seed output plant^{-1}
Jan.	P	Seed sowing / Dormancy period							
	S	7.80±2.05	4.4±1.67	20.4±3.4	89.76±34.07	–	–	–	–
Feb.	P	16.12±1.68	9.2±2.6	16.35±2.07	312.61±94.18	–	–	–	–
	S	19.08^{ns}±4.26	16.4*±2.07	26.13*±8.2	428.53^{ns}±54.09	–	–	–	–
Mar.	P	27.18±2.05	24.8±6.4	32.15±9.3	2289.1±459.8	8.4±2.41	1.4±0.55	–	–
	S	33.14^{ns}±5.49	37.6*±3.85	22.83*±5.8	858.41*±88.12	2.2*±0.4	–	–	–
Apr.	P	35.24±2.98	38.6±2.88	37.35±6.6	2980.53±422.1	17.2±3.35	12.2±2.59	2.8±1.30	–
	S	40.75^{ns}±2.0	60.4*±3.9	20.93*±4.5	1264.17*±81.63	9.2*±2.68	–	–	–
May	P	45.57±5.77	41.4±4.5	41.5±6.8	3378.1±358.98	19.4±3.21	15.8±3.11	5.8±3.03	4.2±1.79
	S	65.16*±7.1	65.8*±9.3	21.85*±5.0	1437.73*±203.0	14.2^{ns}±4.15	–	–	–
Jun.	P	46.48±3.97	39.4±3.51	35.78±12.87	2447.35±518.8	10.2±2.78	1.2±0.45	1.2±0.94	0.8±0.45
	S	75.38*±3.4	53.2^{ns}±6.6	19.5*±5.87	1037.4*±128.7	8.4^{ns}±2.4	–	–	–
Jul.	P	48.04±4.5	36.4±5.86	39.5±7.3	3017.8±560.9	11.6±3.29	20.4±1.67	–	–
	S	102.96*±10.00	83.2*±6.65	23.18*±4.82	1928.58*±154.15	62.6*±7.83	3.8*±0.84	–	–
Aug.	P	49.19±5.1	44.4±5.55	33.4±3.9	2818.96±130.26	13.4±3.05	17.4±4.39	7.6±2.3	1.2±0.45
	S	105.04*±14.17	129.4*±20.27	25.09^{ns}±6.43	3246.65^{ns}±508.57	74.6*±16.1	13.2^{ns}±2.28	10.4^{ns}±1.14	–
Sep.	P	50.28±3.73	40.4±5.42	33.95±2.3	5781.1±671.48	15.8±4.15	16.2±2.78	19.2±2.39	5.4±1.52
	S	112.35*±8.0	202.8*±14.69	23.92*±5.26	4850.98^{ns}±351.39	58.4*±5.59	19.8^{ns}±2.17	25.6^{ns}±3.36	1.8*±0.8
Oct.	P	50.98±2.07	55.6±5.13	40.45±5.6	4271.5±384.3	14.2±3.79	11.2±3.49	17.4±2.41	13.2±2.86
	S	112.84*±20.6	205.4*±27.96	24.65*±6.29	5063.11^{ns}±689.20	55.4*±12.46	9.8^{ns}±2.59	30.4*±2.7	17.8^{ns}±3.96
Nov.	P	51.99±1.74	51.8±5.26	32.35±9.8	3293.23±331.91	7.6±2.7	5.2±2.28	21.8±5.07	17.2±1.92
	S	116.01*±7.0	181.8*±12.87	26.69^{ns}±7.89	4852.24*±343.50	45.4*±4.88	2.8*±0.8	8.8*±1.34	29.2*±2.59
Dec.	P	51.34±1.42	48.2±3.7	20.25±7.3	1988.55±319.95	1.2±0.84	0.8±0.45	7.4±2.8	9.8±3.63
	S	115.76*±8.22	129.2*±7.3	25.64^{ns}±6.76	3312.69*±187.17	–	1.2*±0.4	7.6^{ns}±1.34	15.6*±3.8

Mean ± S.D., P = Pot cultivated plants, S = Site plants

Table 25. Monthly chlorophyll content (Chlorophyll a, b and total), relative water content (RWC) and stomatal responses (number and index) of *Mirabilis jalapa* at Site 1 in wild and pots under cultivation (presented as Figure 11 and 12).

Months		Chlorophyll a	Chlorophyll b	Total Chlorophyll	RWC	Stomata number (adaxial)	Stomatal index (adaxial)	Stomata number (abaxial)	Stomatal index (abaxial)
Jan.	P	–	–	–	–	–	–	–	–
	S	0.780±0.01	0.385±0.07	1.165±0.02	79.42±2.4	0.60±0.4	1.55±1.0	14.67±1.7	19.58±0.8
Feb.	P	0.839±0.09	0.309±0.01	1.199±0.12	87.73±3.9	–	–	11.10±1.4	24.40±2.0
	S	0.747^{ns}±0.02	0.441*±0.02	1.190^{ns}±0.01	88.75^{ns}±4.1	0.50±0.4	1.90±0.4	11.33^{ns}±1.2	22.83^{ns}±1.9
Mar.	P	0.885±0.06	0.357±0.05	1.236±0.20	89.18±4.8	–	–	11.20±1.3	26.50±3.3
	S	0.869^{ns}±0.10	0.308^{ns}±0.05	1.180^{ns}±0.04	90.35^{ns}±5.2	0.70±0.4	2.63±0.5	10.33^{ns}±1.6	20.39^{ns}±1.8
Apr.	P	0.887±0.07	0.388±0.04	1.268±0.15	88.92±3.9	–	–	11.50±1.6	27.30±3.3
	S	0.889^{ns}±0.01	0.321^{ns}±0.04	1.210^{ns}±0.08	92.61^{ns}±3.3	0.90±0.5	5.28±1.6	7.22*±1.4	19.17*±3.0
May	P	0.908±0.04	0.410±0.04	1.301±0.18	85.27±7.6	–	–	13.80±2.1	28.00±1.0
	S	0.718^{ns}±0.03	0.484^{ns}±0.05	1.200^{ns}±0.10	85.79^{ns}±5.2	1.86±0.7	3.94±0.3	9.67*±1.0	17.37*±2.6
Jun.	P	0.921±0.04	0.427±0.05	1.335±0.32	86.06±5.9	–	–	15.3±2.3	29.10±1.8
	S	0.509*±0.05	0.267*±0.06	0.776*±0.12	86.24^{ns}±3.4	1.66±1.0	6.95±2.7	11.53^{ns}±2.5	18.79*±2.3
Jul.	P	0.949±0.01	0.414±0.06	1.245±0.28	86.65±2.7	–	–	15.60±3.7	28.60±1.2
	S	0.479*±0.15	0.177*±0.08	0.656*±0.32	89.29^{ns}±6.1	–	–	9.95*±1.1	19.32*±1.3
Aug.	P	0.786±0.01	0.443±0.03	1.143±0.29	85.94±2.6	–	–	18.80±2.0	29.30±1.1
	S	0.888^{ns}±0.21	0.527^{ns}±0.14	1.420^{ns}±0.47	81.46^{ns}±2.1	–	–	16.67^{ns}±1.5	24.39^{ns}±2.4
Sep.	P	0.759±0.03	0.457±0.04	1.156±0.17	85.04±1.9	–	–	18.40±1.3	29.10±2.1
	S	0.778^{ns}±0.01	0.362^{ns}±0.10	1.140^{ns}±0.56	83.04^{ns}±3.3	–	–	11.43*±1.6	21.60^{ns}±1.7
Oct.	P	0.797±0.01	0.397±0.01	1.053±0.34	85.32±2.7	–	–	16.80±3.2	31.00±1.6
	S	0.688^{ns}±0.01	0.434^{ns}±0.01	0.971^{ns}±0.23	79.59^{ns}±3.0	–	–	10.80*±1.7	21.68*±2.4
Nov.	P	0.729±0.04	0.256±0.03	0.972±0.32	83.67±2.0	–	–	15.40±1.9	25.90±1.4
	S	0.661^{ns}±0.11	0.414*±0.06	1.080^{ns}±0.15	77.34^{ns}±3.5	–	–	9.80*±1.0	27.03^{ns}±2.5
Dec.	P	0.726±0.05	0.243±0.02	0.964±0.12	84.39±2.8	–	–	12.70±1.7	23.30±3.2
	S	0.518*±0.23	0.453*±0.04	1.120^{ns}±0.09	75.38^{ns}±3.6	–	–	14.30^{ns}±3.7	20.82^{ns}±1.1

Mean ± S.D., P = Pot cultivated plants, S = Site plants, stomata number = per cm^2 area

Table 26 Monthly vegetative and reproductive growth of selected invasive *Ruellia tuberosa* in pots (under cultivation) and at Site 2 and Site 3 (in wild) respectively (presented as Figure 17 and 20)

Months		Plant height	Leaf plant^{-1}	Leaf area	Total leaf area plant^{-1}	Flower bud plant^{-1}	Flower plant^{-1}	Fuit plant^{-1}	Seeds pod^{-1}	Seed output plant^{-1}
	P	–	–	–	–	–	–	–	–	–
Apr	S2	–	–	–	–	–	–	–	–	–
	S3	–	–	–	–	–	–	–	–	–
	P	15 28±1 6	10 2±3 5	19 11±4 3	155 55±53 22	–	–	–	–	–
May	S2	11 25^{ns}±1 1	10 6^{ns}±3 6	13 66*±3 4	144 8^{ns}±48 9	–	–	–	–	–
	S3	12 72^{ns}±4 0	7 2*±3 0	13 13*±3 13	94 54*±39 78	–	–	–	–	–
	P	25 76±2 1	11 2±4 3	23 38±7 9	261 86±100 53	3 2±1 9	2 4±1 1	0 8±0 4	–	–
Jun	S2	14 49*±1 4	17 4*±2 3	19 10^{ns}±3 3	332 34^{ns}±43 93	–	–	–	–	–
	S3	19 4^{ns}±2 2	9 2^{ns}±1 9	19 45^{ns}±3 29	178 94*±36 96	1 2*±0 8	–	–	–	–
	P	34 26±4 6	23 8±4 2	30 28±10 8	720 66±125 66	6 4±1 9	2 8±0 8	2 6±0 6	32 6±3 6	84 76±6 92
Jul	S2	24 24*±2 4	25 2^{ns}±2 9	20 69*±3 8	521 39*±59 17	5 2^{ns}±0 8	0 8*±0 4	0 8*±0 4	–	–
	S3	25 26^{ns}±4 3	19 8^{ns}±3 6	19 97*±4 18	395 4*±71 09	4 4*±1 8	1 6*±0 6	–	–	–
	P	41 73±4 1	24 4±2 2	35 45±4 6	864 98±77 64	12 0±3 3	3 6±1 5	4 6±1 8	26 2±2 9	120 52±9 84
Aug	S2	28 4*±4 2	20 2^{ns}±3 0	15 67*±4 22	316 53*±47 01	6 8*±1 1	2 2*±0 8	0 8*±0 8	26 2*±2 9	20 96*±1 71
	S3	27 24*±7 5	12 2*±2 9	19 89*±2 86	242 66*±56 89	3 6*±1 8	2 4*±0 9	1 5*±0 8	22 8^{ns}±42	34 2*±2 79
	P	56 45±2 5	28 2±2 1	41 21±7 8	750 02±84 48	14 2±3 9	5 8±2 2	3 8±1 6	30 8±6 4	117 04±9 56
Sep	S2	33 58*±3 2	23 8^{ns}±2 9	16 32*±4 03	388 42*±47 33	3 6*±1 5	1 6*±0 5	2 6*±0 9	21 4*±5 3	24 00*±1 96
	S3	32 92*±1 0	17 2*±2 2	15 96*±3 26	274 5*±35 11	6 4*±2 3	2 2*±0 8	3 2^{ns}±0 8	28 2^{ns}±2 9	90 24^{ns}±7 37
	P	61 14±6 7	27 6±2 6	27 39±6 3	482 06±71 49	22 8±3 4	8 4±2 4	7 6±2 0	31 8±5 4	241 68±19 73
Oct	S2	35 37*±5 3	17 6*±3 4	16 78*±4 2	295 33*±57 05	1 8*±1 4	0 6*±0 5	3 2*±0 8	27 6^{ns}±6 5	88 36*±7 21
	S3	35 6*±3 6	19 2*±4 3	15 60*±2 88	299 52*±67 39	2 6*±1 1	1 8*±0 8	3 8*±1 2	26 4^{ns}±6 2	100 32*±8 19
	P	62 7±6 6	25 2±4 0	24 31±4 4	369 5±97 73	5 2±3 2	2 4±0 8	9 0±2 7	29 6±1 8	266 4±21 75
Nov	S2	36 23*±3 2	15 4*±2 5	15 52*±4 76	239 1*±38 8	1 2*±0 8	–	3 0*±1 0	27 2^{ns}±1 9	81 20*±6 63
	S3	37 42*±5 9	24 6^{ns}±9 9	18 35^{ns}±3 05	451 41^{ns}±81 67	1 8*±0 8	0 4*±0 5	4 6*±1 5	22 6^{ns}±3 2	103 96*±8 49
	P	64 26±3 1	18 8±3 6	21 73±5 8	408 5±64 1	0 6±0 8	0 8±0 5	1 2±0 8	32 4±4 6	38 88±3 17
Dec	S2	36 75*±4 7	16 2^{ns}±3 2	15 88^{ns}±5 66	257 26*±50 82	–	–	1 8*±0 8	25 8^{ns}±2 2	46 44^{ns}±3 79
	S3	37 75*±4 2	10 2*±3 1	19 39^{ns}±3 40	197 78*±60 12	–	–	2 8*±1 2	25 8^{ns}±1 8	72 24*±5 90
	P	64 37±3 3	14 0±3 4	19 40±3 42	267 54±64 78	–	–	1 4±0 8	27 4±7 6	38 36±3 13
Jan	S2	34 8*±4 2	9 6*±1 8	17 62^{ns}±5 07	169 15*±31 72	–	–	0 6*±0 5	21 6^{ns}±5 3	12 96*±1 06
	S3	37 27*±2 7	9 4*±2 1	19 14^{ns}±3 2	179 92*±40 19	–	–	1 2^{ns}±0 4	18 6*±8 4	22 32*±1 82
	P	64 48±2 3	11 2±3 8	12 50±1 2	140 0±47 13	–	–	0 2±0 5	29 8±3 6	5 96±0 49
Feb	S2	–	–	–	–	–	–	–	–	–
	S3	37 54*±2 5	8 4^{ns}±2 1	21 18*±4 04	177 9^{ns}±55 28	–	–	–	–	–
	P	64 52±2 4	8 8±4 2	10 27±3 6	90 38±42 62	–	–	–	–	–
Mar	S2	–	–	–	–	–	–	–	–	–
	S3	–	–	–	–	–	–	–	–	–

Mean ± S D P = Pot cultivated plants S2 – Site 2 plants S3 = Site 3 plants

Table 27 Monthly chlorophyll content (Chlorophyll a, b and total), relative water content (RWC) and stomatal (number and index) of selected invasive *Ruellia tuberosa* in pots (cultivation), Site 2 and Site 3 respectively (presented as Figure 18 and 19)

Months		Chlorophyll a	Chlorophyll b	Total Chlorophyll	RWC	Stomata number (adaxial)	Stomatal index (adaxial)	Stomata number (abaxial)	Stomatal index (abaxial)
Apr	P	–	–	–	–	–	–	–	–
	S2	–	–	–	–	–	–	–	–
	S3	–	–	–	–	–	–	–	–
May	P	0 524±0 07	0 381±0 04	0 906±0 02	89 06±3 58	4 78±1 12	10 31±1 25	27 06±1 45	36 38±2 2
	S2	0 421^{ns}±0 19	0 246*±0 03	0 667^{ns}±0 59	77 68^{ns}±4 5	0 67*±0 4	1 76*±1 1	16 66*±0 96	35 52^{ns}±4 07
	S3	0 457^{ns}±0 67	0 189*±0 02	0 646*±0 21	89 36^{ns}±2 6	1 34*±0 7	4 31*±2 71	15 33*±0 79	29 82^{ns}±3 65
Jun	P	0 569±0 02	0 391±0 04	0 901±0 015	87 37±4 15	5 40±0 86	13 38±1 42	27 78±2 32	35 21±2 83
	S2	0 243*±0 05	0 198*±0 06	0 441*±0 03	86 37^{ns}±3 2	0 56*±0 4	1 55*±0 9	15 26*±2 59	26 55^{ns}±3 89
	S3	0 329*±0 02	0 290^{ns}±0 08	0 619*±0 38	87 3^{ns}±1 7	1 34*±0 52	5 23*±1 7	15 33*±0 64	32 6^{ns}±2 37
Jul	P	0 618±0 03	0 420±0 05	1 035±0 069	85 54±4 54	6 80±0 96	12 39±1 35	25 74±1 88	34 45±1 72
	S2	0 365*±0 12	0 153*±0 08	0 518*±0 29	90 63^{ns}±4 5	0 74*±0 29	1 86*±0 15	17 30*±1 9	34 37^{ns}±3 96
	S3	0 494^{ns}±0 12	0 291*±0 04	0 785^{ns}±0 15	91 04^{ns}±3 6	2 32*±0 72	8 09*±1 6	13 33*±1 59	35 15^{ns}±3 5
Aug	P	0 693±0 01	0 399±0 01	1 07±0 12	85 66±2 57	6 3±0 64	10 41±1 06	26 00±2 03	35 02±2 18
	S2	0 537^{ns}±0 09	0 315^{ns}±0 15	0 852^{ns}±0 17	89 5^{ns}±2 0	0 80*±0 31	3 09*±0 89	13 66*±2 17	35 61^{ns}±4 10
	S3	0 575^{ns}±0 1	0 255*±0 05	0 730*±0 08	82 64^{ns}±2 6	3 52*±0 93	14 17^{ns}±3 25	17 06*±1 55	36 81^{ns}±3 53
Sep	P	0 726±0 03	0 353±0 04	1 08±0 26	86 35±3 66	6 72±0 95	10 79±1 85	26 78±1 12	35 79± 62
	S2	0 457*±0 07	0 189*±0 02	0 646*±0 34	85 47^{ns}±4 2	1 42*±0 7	3 52*±0 92	19 66^{ns}±2 67	38 50^{ns}±2 3
	S3	0 465*±0 03	0 243*±0 02	0 708*±0 39	89 54^{ns}±1 9	6 26^{ns}±1 32	18 46*±3 9	18 34*±0 65	37 94^{ns}±1 53
Oct	P	0 711±0 03	0 298±0 03	1 01±0 3	86 76±2 8	5 78±1 03	11 23±1 05	27 4±1 36	34 78±2 31
	S2	0 569^{ns}±0 02	0 143*±0 01	0 712*±0 93	83 58^{ns}±2 4	0 72*±0 44	1 91*±0 76	14 66*±1 25	32 80^{ns}±2 7
	S3	0 585^{ns}±0 02	0 192*±0 01	0 728*±0 46	77 54^{ns}±3 6	4 14*±1 77	17 18*±3 37	20 66^{ns}±1 41	41 05^{ns}±1 49
Nov	P	0 708±0 04	0 256±0 239	0 964±0 03	85 59±2 9	5 26±0 79	11 34±2 24	25 66±1 29	33 36±1 55
	S2	0 439*±0 05	0 185*±0 06	0 624*±0 48	80 79^{ns}±3 7	0 66*±0 35	1 11*±0 56	16 34*±1 33	36 76^{ns}±4 24
	S3	0 494*±0 09	0 225^{ns}±0 04	0 719*±0 21	79 29^{ns}±2 6	4 66^{ns}±0 78	9 09^{ns}±3 06	17 32*±1 59	34 13^{ns}±2 37
Dec	P	0 571±0 02	0 239±0 02	0 810±0 02	83 05±3 8	4 66±0 93	11 79±1 28	23 86±1 28	33 79±1 86
	S2	0 315*±0 12	0 169*±0 6	0 484*±0 23	78 22^{ns}±4 7	0 66*±0 35	1 74*±0 58	19 66^{ns}±1 19	35 72^{ns}±3 11
	S3	0 329*±0 16	0 203^{ns}±0 05	0 532^{ns}±0 78	75 51^{ns}±3 4	4 33^{ns}±0 79	10 72^{ns}±2 20	20 68^{ns}±1 17	31 66^{ns}±1 39
Jan	P	0 694±0 01	0 219±0 038	0 913±0 02	80 41±4 0	3 08±1 09	12 39±1 84	23 06±1 57	32 49±1 48
	S2	0 407*±0 1	0 245^{ns}±0 02	0 652*±0 35	80 68^{ns}±3 8	0 26*±0 4	0 95*±1 17	20 5^{ns}±2 26	36 59^{ns}±3 38
	S3	0 421*±0 18	0 174^{ns}±0 03	0 595*±0 21	74 78^{ns}±4 9	3 34^{ns}±1 13	7 50*±1 87	14 26*±1 98	30 84^{ns}±2 25
Feb	P	0 612±0 02	0 199±0 03	0 811±0 29	84 21±7 0	3 46±0 92	12 08±1 94	23 18±1 73	32 75±1 96
	S2	–	–	–	–	–	–	–	–
	S3	0 467^{ns}±0 01	0 218^{ns}±0 02	0 685^{ns}±0 16	74 13^{ns}±3 6	1 66*±0 69	3 50*±0 96	16 18*±1 59	32 56^{ns}±3 18
Mar	P	0 513±0 03	0 186±0 02	0 699±0 03	82 75±2 7	3 74±0 94	11 84±1 36	23 54±1 21	32 01±1 72
	S2	–	–	–	–	–	–	–	–
	S3	–	–	–	–	–	–	–	–

Mean ± S D P = Pot cultivated plants S2 Site 2 plants S3 = Site 3 plants stomata number = per cm^2 area

Table 28. A comparative account of proportion of leaf tissues (Dermal system, Palisade and Spongy parenchyma, vascular area and total leaf tissue area) of *Mirabilis jalapa* and *Ruellia tuberosa* grown in pots and at Site 1 (invaded by *Mirabilis jalapa*), Site 2 and 3 (invaded by *Ruellia tuberosa*) (presented as Figure 27).

Leaf tissues	**Pot (*Mirabilis jalapa*)**	**Site 1**	**Pot (*Ruellia tuberosa*)**	**Site 2**	**Site 3**
Dermal system (μm^2)	1026.1±59.5	1178.4±54.0	1099.5±69.2	1320.3±63. 5	1140.4±66.9
Palisade parenchyma (μm^2)	1824.5±96.9	2356.0±97.6	1828.1±99.2	2279.8±94.1	1899.8±93.2
Spongy parenchyma (μm^2)	2140.4±101.7	3162.6±108.4	1945.9±109.3	1657.1±109.6	1457.1±105.6
Vascular area (μm^2)	101.6±15.6	152.4±20.6	51.1±10.7	62.9±19.1	62.9±20.2
Total leaf tissue area (μm^2)	5092.6±221.4	6849.4±226.4	4924.6±217.7	5320.1±208.0	4560.2±220.1

Mean ± S.D. (values show area of each tissue system in μm^2 in a vertical section of leaf)

Table 29. Plant height (cm) of selected invasive plants treated with varying water regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 28).

Days after treatment	Treatments (watering intervals)					
	W_1	W_2	W_3	W_4	W_5	Mean
			Mirabilis jalapa			
			30 days after germination			
7	15.12±2.34	17.35±1.92	16.78±1.30	14.87±0.60	11.95±0.67	15.21
14	21.37±1.38	19.21±1.88	18.36±1.98	15.23±0.87	12.68±0.60	17.37
21	26.59±2.72	28.73±0.77	21.08±1.16	15.74±1.13	13.45±0.88	21.12
28	30.28±1.07	32.18±2.59	23.45±1.72	16.37±0.99	13.85±0.46	23.23
35	30.74±1.96	33.41±4.27	24.35±1.38	16.63±1.21	13.97±1.01	23.82
Mean	24.82	26.18	20.80	15.77	13.18	
LSD at 5%	W = 1.22	D = 1.22	I = 2.73			
LSD at 1%	W = 1.62	D = 1.62	I = 3.63			
			60 days after germination			
7	31.61±1.57	32.59±1.96	30.25±1.86	29.19±1.65	27.42±0.85	30.29
14	32.87±1.53	34.37±1.10	32.67±2.56	29.68±1.21	27.64±1.01	31.48
21	35.35±2.06	37.95±1.20	35.38±1.01	30.53±1.05	27.79±1.17	33.40
28	39.70±0.83	40.12±0.89	37.17±1.78	30.97±1.67	27.83±1.09	35.12
35	41.28±1.81	40.98±0.23	38.33±1.47	31.17±1.92	27.81±1.26	35.84
Mean	36.16	37.20	34.76	30.31	27.70	
LSD at 5%	W = 1.01	D = 1.01	I = 2.25			
LSD at 1%	W = 1.34	D = 1.34	I = 3.00			
			Ruellia tuberosa			
			30 days after germination			
7	14.87±1.36	14.27±1.96	14.47±1.78	13.90±1.54	12.37±1.55	14.25
14	15.07±1.72	17.27±2.55	15.47±2.06	14.97±1.42	12.73±1.68	15.24
21	18.97±0.49	19.73±2.02	17.10±2.27	15.97±2.27	13.10±1.39	16.97
28	20.37±1.14	21.23±2.18	18.37±3.11	16.30±1.40	13.43±1.00	17.80
35	22.57±1.67	22.44±3.10	19.07±3.08	16.53±1.59	13.77±1.05	18.59
Mean	18.37	18.99	16.89	15.53	13.08	
LSD at 5%	W = 1.40	D = 1.40	I = 3.13			
LSD at 1%	W = 1.86	D = 1.86	I = 4.16			
			60 days after germination			
7	22.97±4.22	21.33±3.52	19.77±1.82	19.03±1.42	18.17±1.89	20.39
14	23.10±4.07	24.17±3.27	21.07±1.26	19.80±1.55	18.27±1.88	21.36
21	29.97±3.11	29.07±3.27	22.30±3.67	20.23±2.12	18.37±1.79	23.99
28	32.20±1.51	33.20±3.74	23.47±3.40	21.63±3.52	18.67±1.88	25.75
35	35.53±2.33	36.87±2.60	25.87±1.22	22.97±2.93	18.87±2.06	27.88
Mean	28.75	28.93	22.49	20.73	18.47	
LSD at 5%	W = 1.93	D = 1.93	I = 4.32			
LSD at 1%	W = 2.57	D = 2.57	I = 5.75			

Mean ± S.D.

W_1 – W_5 = Watering intervals; W_1 = Daily watering, W_2 = Alternate days watering, W_3 = 3 days interval, W_4 = 5 days interval, W_5 = 10 days intervals (plants highly wilted).

W = Watering intervals; D = Days after treatment; I = Interaction

Table 30. Leaf plant^{-1} of selected invasive plants treated with varying water regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 29).

Days after treatment	Treatments (watering intervals)					
	W_1	W_2	W_3	W_4	W_5	Mean
			Mirabilis jalapa			
			30 days after germination			
7	20.67±2.08	19.33±3.06	16.67±2.08	16.33±1.53	15.67±2.52	17.73
14	24.33±2.52	23.33±2.08	16.67±2.31	15.67±1.53	12.67±2.52	20.13
21	24.00±2.00	27.67±2.08	18.67±2.89	14.67±2.08	9.33±1.53	18.00
28	29.67±1.53	28.67±1.53	19.67±2.52	12.67±3.79	7.33±2.08	19.40
35	30.33±3.06	31.33±1.53	19.67±1.15	11.33±2.08	6.67±1.53	19.33
Mean	25.80	26.07	18.27	14.13	10.33	
LSD at 5%	W = 1.30	D = 1.30	I = 2.91			
LSD at 1%	W = 1.73	D = 1.73	I = 3.87			
			60 days after germination			
7	33.67±2.52	31.33±4.51	30.67±2.08	29.33±4.16	27.33±3.79	30.47
14	36.33±2.52	33.33±2.08	31.67±2.08	27.67±2.08	26.67±3.21	31.13
21	36.67±2.08	36.33±2.31	32.33±2.31	26.67±2.31	24.33±2.08	31.27
28	38.33±1.53	36.67±3.21	33.67±1.53	25.67±1.15	23.33±2.52	31.53
35	40.33±2.08	38.33±3.21	33.67±4.73	25.33±2.08	20.67±1.53	31.67
Mean	37.07	35.20	32.40	26.93	24.47	
LSD at 5%	W = 1.67	D = NS	I = 3.72			
LSD at 1%	W = 2.21	D = NS	I = 4.95			
			Ruellia tuberosa			
			30 days after germination			
7	10.33±2.08	10.67±2.52	11.33±4.51	10.67±2.31	10.33±3.51	10.67
14	17.67±2.08	18.33±3.06	9.33±2.52	9.67±3.51	8.67±2.52	12.73
21	20.33±4.62	18.67±2.89	9.67±4.51	8.67±2.52	8.33±1.53	13.13
28	21.67±3.06	20.33±3.79	10.33±2.89	8.33±1.53	7.33±1.53	13.60
35	24.67±2.52	26.67±1.53	13.67±2.31	8.00±1.73	6.67±2.52	15.93
Mean	18.93	18.93	10.87	9.07	8.27	
LSD at 5%	W = 1.80	D = 1.80	I = 4.03			
LSD at 1%	W = 2.39	D = 2.39	I = 5.35			
			60 days after germination			
7	9.33±6.22	8.67±5.78	9.67±6.45	8.67±5.78	9.33±6.22	9.13
14	11.33±7.55	11.67±7.78	10.67±7.11	8.33±5.55	7.67±5.11	9.93
21	12.67±8.45	11.67±7.78	11.33±7.55	7.67±5.11	6.33±4.22	9.93
28	13.33±8.89	12.33±8.22	10.33±6.89	6.67±4.45	5.67±3.78	9.67
35	14.33±9.55	14.33±9.55	10.67±7.11	6.33±4.22	4.67±3.11	10.07
Mean	12.20	11.73	10.53	7.53	6.73	
LSD at 5%	W = 1.28	D = NS	I = 2.86			
LSD at 1%	W = 1.70	D = NS	I = 3.81			

Mean ± S.D.

$W_1 - W_5$ = Watering intervals; W_1 = Daily watering, W_2 = Alternate days watering, W_3 = 3 days interval, W_4 = 5 days interval, W_5 = 10 days intervals.

W = Watering intervals; D = Days after treatment; I = Interaction; NS = Non significant

Table 31. Leaf area expansion (cm^2) of selected invasive plants treated with varying water regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 30).

Days after treatment	Treatments (watering intervals)					
	W_1	W_2	W_3	W_4	W_5	Mean
			Mirabilis jalapa			
			30 days after germination			
7	6.68±0.72	6.93±2.61	6.45±3.33	6.22±2.10	5.75±1.84	6.41
14	13.27±1.49	18.65±2.56	10.64±2.47	7.34±1.64	6.98±0.92	11.38
21	22.98±1.91	20.35±1.28	12.78±2.38	9.12±1.32	8.12±1.51	14.67
28	27.25±3.78	31.49±2.58	16.10±2.46	12.68±2.58	8.25±1.03	19.15
35	32.12±1.69	33.81±4.60	21.22±2.89	14.57±4.58	8.79±1.20	22.10
Mean	20.46	22.25	13.44	9.99	7.58	
LSD at 5%	W = 1.63	D = 1.63	I = 3.64			
LSD at 1%	W = 2.17	D = 2.17	I = 4.84			
			60 days after germination			
7	8.73±1.25	8.48±1.61	7.86±1.97	7.38±0.85	6.68±1.08	7.83
14	19.49±1.08	16.12±1.89	13.08±1.56	11.49±2.49	9.79±1.37	13.99
21	24.37±3.09	27.86±1.32	17.34±2.72	15.64±1.12	10.34±2.90	19.11
28	29.56±2.70	30.50±1.69	25.08±4.67	17.27±0.37	10.78±1.49	22.64
35	37.35±1.65	35.48±3.97	26.54±1.82	18.22±1.85	11.33±0.46	25.78
Mean	23.90	23.69	17.98	14.00	9.78	
LSD at 5%	W = 1.51	D = 1.51	I = 3.37			
LSD at 1%	W = 2.00	D = 2.00	I = 4.48			
			Ruellia tuberosa			
			30 days after germination			
7	2.75±0.98	2.68±1.00	2.54±0.17	2.08±0.25	1.78±0.45	2.37
14	8.25±2.08	6.10±1.52	7.79±1.38	6.97±1.38	2.59±0.85	6.34
21	15.48±4.39	12.34±2.84	11.43±0.74	8.20±1.03	3.76±1.75	10.24
28	20.32±3.07	17.74±3.34	15.75±2.27	9.05±1.08	5.02±1.73	13.58
35	24.56±1.58	21.27±3.48	17.43±2.12	10.36±3.45	5.12±1.45	15.75
Mean	14.27	12.03	10.99	7.33	3.65	
LSD at 5%	W = 1.46	D = 1.46	I = 3.26			
LSD at 1%	W = 1.94	D = 1.94	I = 4.34			
			60 days after germination			
7	3.49±0.36	3.98±2.22	2.68±0.94	2.75±0.34	1.56±0.43	2.89
14	12.35±4.13	9.75±2.49	6.86±1.47	3.64±1.01	4.27±1.31	7.37
21	18.65±3.99	16.13±1.38	11.73±4.37	7.78±0.70	7.98±1.73	12.45
28	23.34±1.98	21.50±2.24	17.64±4.92	12.61±2.88	8.25±2.62	16.67
35	30.81±3.64	27.48±6.58	20.22±4.90	14.16±5.34	10.12±2.00	20.56
Mean	17.73	15.77	11.83	8.19	6.44	
LSD at 5%	W = 2.23	D = 2.23	I = 4.98			
LSD at 1%	W = 2.96	D = 2.96	I = 6.63			

Mean ± S.D.

$W_1 - W_5$ = Watering intervals; W_1 = Daily watering, W_2 = Alternate days watering, W_3 = 3 days interval, W_4 = 5 days interval, W_5 = 10 days intervals.

W = Watering intervals; D = Days after treatment; I = Interaction

Table 32. Relative water content (%) of selected invasive plants treated with varying water regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 31).

Days after treatment	Treatments (watering intervals)					
	W_1	W_2	W_3	W_4	W_5	Mean
			Mirabilis jalapa			
			30 days after germination			
7	90.65±2.70	91.32±1.19	78.54±0.20	76.52±0.64	70.49±2.07	81.50
14	89.99±2.25	90.74±0.44	77.88±1.37	71.84±1.30	64.29±2.83	78.95
21	88.52±3.22	88.56±0.88	75.67±0.54	68.66±1.55	61.38±1.38	76.56
28	88.67±1.75	88.01±1.82	73.33±0.91	66.98±1.52	60.05±2.41	75.41
35	87.13±1.86	86.63±1.35	70.05±3.25	64.24±1.78	58.95±1.96	73.40
Mean	88.99	89.05	75.09	69.65	63.03	
LSD at 5%	W = 1.33	D = 1.33	I = 2.98			
LSD at 1%	W = 1.77	D = 1.77	I = 3.96			
			60 days after germination			
7	89.59±29.86	89.98±29.99	87.29±29.10	84.03±28.01	78.24±26.08	85.83
14	88.52±29.51	88.70±29.57	87.54±29.18	80.11±26.70	75.99±25.33	84.17
21	88.40±29.47	87.54±29.18	85.13±28.38	78.14±26.05	75.15±25.05	82.87
28	86.64±28.88	85.05±28.35	81.84±27.28	71.87±23.96	66.54±22.18	78.39
35	86.37±28.79	85.20±28.40	74.04±24.68	67.44±22.48	63.08±21.03	75.23
Mean	87.90	87.29	83.17	76.32	71.80	
LSD at 5%	W = 1.88	D = 1.88	I = 4.20			
LSD at 1%	W = 2.50	D = 2.50	I = 5.59			
			Ruellia tuberosa			
			30 days after germination			
7	89.59±5.67	89.98±2.08	87.29±1.56	84.03±1.04	78.24±1.94	85.83
14	88.52±1.89	88.70±2.50	87.54±1.08	80.11±2.50	75.99±4.80	84.17
21	88.40±2.52	87.54±2.65	85.13±1.68	78.14±3.80	75.15±1.59	82.87
28	86.64±1.50	85.05±3.78	81.84±4.03	71.87±1.05	66.54±2.87	78.39
35	86.37±3.05	85.20±6.80	74.04±2.08	67.44±3.70	63.08±3.89	75.23
Mean	87.90	87.29	83.17	76.32	71.80	
LSD at 5%	W = 1.92	D = 1.92	I = 4.29			
LSD at 1%	W = 2.55	D = 2.55	I = 5.70			
			60 days after germination			
7	87.26±29.09	88.12±29.37	85.68±28.56	83.64±27.88	80.21±26.74	84.98
14	88.15±29.38	87.56±29.19	85.24±28.41	79.55±26.52	78.84±26.28	83.87
21	88.59±29.53	85.54±28.51	83.92±27.97	77.37±25.79	75.58±25.19	82.20
28	85.37±28.46	84.39±28.13	83.15±27.72	75.95±25.32	72.34±24.11	80.24
35	84.26±28.09	84.18±28.06	79.38±26.46	75.64±25.21	71.21±23.74	78.93
Mean	86.73	85.96	83.47	78.43	75.64	
LSD at 5%	W = 1.22	D = 1.22	I = 2.72			
LSD at 1%	W = 1.62	D = 1.62	I = 3.62			

Mean ± S.D.

$W_1 - W_5$ = Watering intervals; W_1 = Daily watering, W_2 = Alternate days watering, W_3 = 3 days interval, W_4 = 5 days interval, W_5 = 10 days intervals.

W = Watering intervals; D = Days after treatment; I = Interaction; NS = Non significant

Table 33. Chlorophyll a (mg g-1 fresh weight) of selected invasive plants treated with varying water regimes at two stages of growth (30 and 60 days from germination) (presented as Figure 32).

Days after treatment	Treatments (watering intervals) W_1	W_2	W_3	W_4	W_5	Mean
			Mirabilis jalapa			
			30 days after germination			
7	0.835±0.009	0.862±0.021	0.823±0.013	0.819±0.016	0.795±0.007	0.827
14	0.864±0.012	0.874±0.010	0.816±0.015	0.794±0.017	0.708±0.016	0.811
21	0.889±0.013	0.896±0.007	0.807±0.027	0.797±0.013	0.686±0.008	0.815
28	0.898±0.033	0.903±0.014	0.798±0.013	0.743±0.024	0.645±0.011	0.797
35	0.910±0.015	0.909±0.023	0.728±0.010	0.648±0.023	0.588±0.010	0.757
Mean	0.879	0.889	0.794	0.760	0.684	
LSD at 5%	W = 0.012	D = 0.012	I = 0.026			
LSD at 1%	W = 0.015	D = 0.015	I = 0.034			
			60 days after germination			
7	0.868±0.016	0.876±0.006	0.854±0.016	0.833±0.007	0.828±0.017	0.852
14	0.878±0.019	0.898±0.013	0.821±0.010	0.817±0.014	0.786±0.011	0.840
21	0.886±0.026	0.921±0.024	0.796±0.012	0.774±0.009	0.738±0.016	0.823
28	0.894±0.011	0.923±0.018	0.783±0.012	0.743±0.020	0.698±0.032	0.808
35	0.904±0.018	0.923±0.017	0.774±0.008	0.726±0.017	0.678±0.018	0.801
Mean	0.886	0.908	0.806	0.779	0.746	
LSD at 5%	W = 0.012	D = 0.012	I = 0.027			
LSD at 1%	W = 0.016	D = 0.016	I = 0.035			
			Ruellia tuberosa			
			30 days after germination			
7	0.526±0.081	0.518±0.031	0.513±0.034	0.499±0.017	0.411±0.015	0.493
14	0.545±0.035	0.537±0.027	0.498±0.011	0.466±0.042	0.386±0.012	0.486
21	0.553±0.030	0.567±0.031	0.465±0.036	0.435±0.143	0.381±0.021	0.480
28	0.598±0.065	0.550±0.037	0.447±0.025	0.397±0.016	0.375±0.028	0.473
35	0.605±0.040	0.587±0.012	0.437±0.019	0.387±0.048	0.367±0.029	0.477
Mean	0.565	0.552	0.472	0.437	0.384	
LSD at 5%	W = 0.030	D = NS	I = 0.067			
LSD at 1%	W = 0.040	D = NS	I = 0.090			
			60 days after germination			
7	0.504±0.071	0.527±0.010	0.515±0.055	0.468±0.030	0.419±0.018	0.487
14	0.561±0.007	0.549±0.048	0.512±0.054	0.448±0.049	0.416±0.051	0.497
21	0.536±0.028	0.612±0.051	0.507±0.045	0.441±0.017	0.411±0.025	0.501
28	0.635±0.057	0.607±0.091	0.504±0.052	0.439±0.063	0.408±0.026	0.519
35	0.621±0.066	0.635±0.044	0.498±0.020	0.435±0.033	0.403±0.028	0.518
Mean	0.571	0.586	0.507	0.446	0.411	
LSD at 5%	W = 0.018	D = NS	I = NS			
LSD at 1%	W = 0.024	D = NS	I = NS			

Mean ± S.D.

$W_1 - W_5$ = Watering intervals; W_1 = Daily watering, W_2 = Alternate days watering, W_3 = 3 days interval, W_4 = 5 days interval, W_5 = 10 days intervals.

W = Watering intervals; D = Days after treatment; I = Interaction; NS = Non significant

Table 34. Chlorophyll b (mg g^{-1} fresh weight) of selected invasive plants treated with varying water regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 33).

Days after treatment	Treatments (watering intervals)					
	W_1	W_2	W_3	W_4	W_5	Mean
			Mirabilis jalapa			
			30 days after germination			
7	0.353±0.021	0.360±0.009	0.347±0.007	0.343±0.012	0.332±0.008	0.347
14	0.359±0.010	0.372±0.015	0.328±0.017	0.327±0.023	0.284±0.011	0.334
21	0.368±0.004	0.379±0.012	0.292±0.010	0.276±0.010	0.238±0.013	0.311
28	0.382±0.010	0.385±0.014	0.275±0.010	0.238±0.010	0.197±0.009	0.295
35	0.389±0.015	0.392±0.010	0.267±0.013	0.203±0.014	0.152±0.020	0.281
Mean	0.370	0.378	0.302	0.277	0.241	
LSD at 5%	W = 0.009	D = 0.009	I = 0.021			
LSD at 1%	W = 0.012	D = 0.012	I = 0.027			
			60 days after germination			
7	0.386±0.007	0.374±0.016	0.367±0.007	0.354±0.010	0.343±0.009	0.365
14	0.393±0.011	0.386±0.010	0.359±0.007	0.337±0.009	0.327±0.013	0.360
21	0.407±0.007	0.399±0.013	0.327±0.014	0.316±0.013	0.294±0.007	0.349
28	0.418±0.006	0.413±0.016	0.321±0.012	0.273±0.022	0.257±0.014	0.336
35	0.422±0.007	0.429±0.011	0.316±0.009	0.264±0.010	0.213±0.011	0.329
Mean	0.405	0.400	0.338	0.309	0.287	
LSD at 5%	W = 0.008	D = 0.008	I = 0.017			
LSD at 1%	W = 0.010	D = 0.010	I = 0.023			
			Ruellia tuberosa			
			30 days after germination			
7	0.378±0.012	0.363±0.035	0.392±0.026	0.347±0.028	0.332±0.022	0.362
14	0.376±0.036	0.386±0.026	0.385±0.047	0.336±0.056	0.319±0.064	0.360
21	0.384±0.022	0.379±0.038	0.382±0.059	0.321±0.060	0.311±0.016	0.355
28	0.398±0.018	0.410±0.037	0.370±0.051	0.318±0.014	0.309±0.031	0.361
35	0.424±0.043	0.417±0.011	0.367±0.054	0.314±0.039	0.305±0.037	0.365
Mean	0.392	0.391	0.379	0.327	0.315	
LSD at 5%	W = 0.023	D = NS	I = NS			
LSD at 1%	W = 0.030	D = NS	I = NS			
			60 days after germination			
7	0.396±0.023	0.401±0.037	0.416±0.046	0.387±0.012	0.383±0.034	0.397
14	0.415±0.014	0.404±0.026	0.391±0.013	0.386±0.038	0.381±0.035	0.395
21	0.421±0.031	0.417±0.030	0.389±0.021	0.379±0.041	0.373±0.046	0.396
28	0.428±0.033	0.433±0.020	0.384±0.024	0.372±0.048	0.367±0.025	0.397
35	0.432±0.060	0.437±0.083	0.379±0.016	0.369±0.063	0.352±0.023	0.394
Mean	0.418	0.418	0.392	0.379	0.371	
LSD at 5%	W = 0.026	D = NS	I = NS			
LSD at 1%	W = 0.034	D = NS	I = NS			

Mean ± S.D.

$W_1 - W_5$ = Watering intervals; W_1 = Daily watering, W_2 = Alternate days watering, W_3 = 3 days interval, W_4 = 5 days interval, W_5 = 10 days intervals.

W = Watering intervals; D = Days after treatment; I = Interaction; NS = Non significant

Table 35. Total chlorophyll (mg g^{-1} fresh weight) of selected invasive plants treated with varying water regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 34).

Days after treatment	Treatments (watering intervals)					
	W_1	W_2	W_3	W_4	W_5	Mean
			Mirabilis jalapa			
			30 days after germination			
7	1.188±0.030	1.198±0.024	1.175±0.022	1.162±0.027	1.127±0.004	1.170
14	1.223±0.015	1.246±0.007	1.144±0.028	1.121±0.039	0.992±0.016	1.145
21	1.257±0.017	1.275±0.005	1.099±0.035	1.073±0.010	0.924±0.007	1.126
28	1.280±0.028	1.288±0.028	1.073±0.017	0.981±0.017	0.842±0.003	1.093
35	1.299±0.001	1.301±0.023	0.995±0.023	0.851±0.036	0.773±0.079	1.044
Mean	1.249	1.262	1.097	1.038	0.932	
LSD at 5%	W = 0.018	D = 0.018	I = 0.040			
LSD at 1%	W = 0.024	D = 0.024	I = 0.054			
			60 days after germination			
7	1.254±0.418	1.250±0.417	1.221±0.407	1.187±0.396	1.171±0.390	1.217
14	1.271±0.424	1.284±0.428	1.180±0.393	1.154±0.385	1.113±0.371	1.200
21	1.293±0.431	1.320±0.440	1.123±0.374	1.090±0.363	1.032±0.344	1.172
28	1.312±0.437	1.336±0.445	1.104±0.368	1.016±0.339	0.955±0.318	1.145
35	1.336±0.445	1.352±0.451	1.077±0.359	0.990±0.330	0.891±0.297	1.129
Mean	1.293	1.308	1.141	1.087	1.032	
LSD at 5%	W = 0.031	D = 0.031	I = 0.070			
LSD at 1%	W = 0.041	D = 0.041	I = 0.093			
			Ruellia tuberosa			
			30 days after germination			
7	0.904±0.069	0.881±0.066	0.905±0.059	0.846±0.044	0.743±0.034	0.856
14	0.921±0.027	0.923±0.053	0.856±0.074	0.771±0.119	0.705±0.068	0.835
21	0.937±0.009	0.946±0.007	0.847±0.060	0.756±0.118	0.692±0.037	0.836
28	0.996±0.075	0.960±0.036	0.817±0.040	0.715±0.015	0.684±0.058	0.834
35	1.029±0.083	1.004±0.022	0.804±0.063	0.701±0.057	0.691±0.045	0.846
Mean	0.957	0.943	0.846	0.758	0.703	
LSD at 5%	W = 0.034	D = NS	I = 0.075			
LSD at 1%	W = 0.045	D = NS	I = 0.100			
			60 days after germination			
7	0.900±0.035	0.928±0.053	0.931±0.050	0.855±0.031	0.802±0.057	0.883
14	0.976±0.045	0.953±0.094	0.903±0.092	0.834±0.042	0.797±0.066	0.892
21	0.957±0.038	1.005±0.074	0.896±0.045	0.820±0.044	0.784±0.011	0.892
28	1.064±0.061	1.040±0.105	0.888±0.059	0.811±0.044	0.775±0.032	0.916
35	1.053±0.046	1.072±0.124	0.877±0.035	0.804±0.053	0.752±0.033	0.912
Mean	0.990	1.000	0.898	0.825	0.782	
LSD at 5%	W = 0.041	D = NS	I = 0.092			
LSD at 1%	W = 0.055	D = NS	I = 0.123			

Mean ± S.D.

$W_1 - W_5$ = Watering intervals; W_1 = Daily watering, W_2 = Alternate days watering, W_3 = 3 days interval, W_4 = 5 days interval, W_5 = 10 days intervals.

W = Watering intervals; D = Days after treatment; I = Interaction; NS = Non significant

Table 36. Above ground biomass (g) of selected invasive plants treated with varying water regimes and recorded after termination of treatment (presented as Figure 35).

Days after Germination	Treatments (watering intervals)						
	W_1	W_2	W_3	W_4	W_5	LSD at	
	Mirabilis jalapa					5%	1%
30	2.1±0.32	1.78±0.32	1.55±0.34	1.35±0.20	1.13±0.06	0.49	0.71
60	3.15±0.21	3.03±0.10	2.17±0.12	2.05±0.16	1.35±0.35	0.41	0.60
	Ruellia tuberosa						
30	2.99±0.83	2.61±1.08	1.24±0.46	0.95±0.38	0.74±0.42	1.39	2.03
60	4.58±1.91	4.28±0.94	3.98±1.43	2.95±1.62	2.33±0.91	NS	NS

Mean ± S.D.
W_1 – W_5 = Watering intervals; W_1 = Daily watering, W_2 = Alternate days watering, W_3 = 3 days interval.
W_4 = 5 days interval, W_5 = 10 days intervals.
NS = Non significant

Table 37. Stomata number and index of adaxial surface of selected invasive *Ruellia tuberosa* with varying water regimes at two stages of growth (30 and 60 days from germination). Stomata were absent on adaxial surface of *Mirabilis jalapa* (presented as Figure 36).

Days after treatment	Treatments (watering intervals)					
	W_1	W_2	W_3	W_4	W_5	Mean
			Stomata number			
			30 days after germination			
7	1.10±0.05	2.87±0.14	2.33±0.12	3.57±0.18	2.80±0.14	2.53
14	2.10±0.11	2.57±0.13	2.03±0.10	4.10±0.21	7.23±0.36	3.61
21	2.90±0.15	3.23±0.16	2.10±0.11	4.23±0.21	8.30±0.42	4.15
28	4.10±0.21	3.67±0.18	2.00±0.10	5.13±0.26	10.03±0.50	4.99
35	4.23±0.21	4.00±0.20	2.20±0.11	6.23±0.31	10.57±0.53	5.45
Mean	2.89	3.27	2.13	4.65	7.79	
LSD at 5%	W = 0.09	D = 0.09	I = 0.20			
LSD at 1%	W = 0.12	D = 0.12	I = 0.27			
			60 days after germination			
7	4.67±0.23	4.57±0.23	3.23±0.16	3.30±0.17	5.90±0.30	4.33
14	4.23±0.21	4.90±0.25	3.77±0.19	4.20±0.21	7.33±0.37	4.89
21	4.90±0.25	5.10±0.26	4.00±0.20	5.77±0.29	8.67±0.43	5.69
28	5.30±0.27	5.57±0.28	3.77±0.19	6.57±0.33	9.23±0.46	6.09
35	6.67±0.33	6.00±0.30	3.57±0.18	7.10±0.36	9.90±0.49	6.65
Mean	5.15	5.23	3.67	5.39	8.21	
LSD at 5%	W = 0.07	D = 0.07	I = 0.15			
LSD at 1%	W = 0.09	D = 0.09	I = 0.20			
			Stomatal index			
			30 days after germination			
7	3.24±0.16	4.04±0.20	4.43±0.22	6.07±0.30	8.13±0.41	5.2
14	5.61±0.28	7.84±0.39	5.27±0.26	9.19±0.46	12.18±0.61	8.0
21	8.39±0.42	9.79±0.49	5.65±0.28	12.24±0.61	14.20±0.71	10.1
28	12.15±0.61	17.88±0.89	5.93±0.30	15.28±0.76	17.48±0.87	13.7
35	14.13±0.71	13.78±0.69	6.09±0.30	18.48±0.92	20.27±1.01	14.6
Mean	8.7	10.7	5.5	12.3	14.5	
LSD at 5%	W = 0.18	D = 0.18	I = 0.41			
LSD at 1%	W = 0.25	D = 0.25	I = 0.55			
			60 days after germination			
7	10.24±1.06	11.97±1.20	11.34±0.67	10.60±0.36	10.14±1.12	10.86
14	11.01±1.16	12.34±1.38	10.83±1.51	10.79±1.39	12.38±1.42	11.47
21	12.73±2.13	11.75±0.86	10.59±1.88	12.30±1.44	13.15±2.11	12.10
28	13.21±2.15	12.26±1.56	10.34±2.15	14.07±2.35	16.85±0.96	13.35
35	13.75±0.75	12.68±1.82	9.97±1.41	17.15±1.06	17.74±0.98	14.26
Mean	12.19	12.20	10.61	12.98	14.05	
LSD at 5%	W = 1.05	D = 1.05	I = 2.35			
LSD at 1%	W = 1.40	D = 1.40	I = 3.13			

Mean ± S.D.

$W_1 - W_5$ = Watering intervals; W_1 = Daily watering, W_2 = Alternate days watering, W_3 = 3 days interval, W_4 = 5 days interval, W_5 = 10 days intervals.

W = Watering intervals; D = Days after treatment; I = Interaction; NS = Non significant

Stomata number = per cm^2 area

Table 38. Stomata number at abaxial surface of selected invasive plants treated with varying water regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 37).

Days after treatment	Treatments (watering intervals)					
	W_1	W_2	W_3	W_4	W_5	Mean
			Mirabilis jalapa			
			30 days after germination			
7	10.10±3.37	9.80±3.27	8.90±2.97	10.80±3.60	11.77±3.92	10.27
14	10.23±3.41	9.77±3.26	10.00±3.33	11.23±3.74	15.57±5.19	11.36
21	10.43±3.48	9.97±3.32	10.10±3.37	12.00±4.00	17.33±5.78	11.97
28	10.77±3.59	9.90±3.30	10.53±3.51	12.99±4.33	19.63±6.54	12.76
35	10.96±3.65	10.23±3.41	11.43±3.81	14.13±4.71	19.67±6.56	13.28
Mean	10.50	9.93	10.19	12.23	16.79	
LSD at 5%	W = 0.72	D = 0.72	I = 1.61			
LSD at 1%	W = 0.96	D = 0.96	I = 2.14			
			60 days after germination			
7	11.23±1.86	11.10±2.71	10.10±1.39	11.43±1.21	14.23±2.16	11.62
14	11.33±1.65	10.67±1.65	11.43±2.42	11.90±1.65	15.43±0.81	12.15
21	11.67±0.65	10.67±1.42	11.57±1.91	12.57±1.03	17.37±2.52	12.77
28	12.00±1.18	10.57±1.91	11.87±0.51	14.33±2.99	17.87±0.51	13.33
35	12.53±1.57	10.53±0.68	11.93±1.86	14.57±1.63	18.23±0.92	13.56
Mean	11.75	10.71	11.38	12.96	16.63	
LSD at 5%	W = 1.13	D = 1.13	I = NS			
LSD at 1%	W = 1.51	D = 1.51	I = NS			
			Ruellia tuberosa			
			30 days after germination			
7	23.23±2.32	23.80±2.38	21.23±2.12	23.33±2.33	24.90±2.49	23.30
14	23.77±2.38	24.23±2.42	19.70±1.97	24.43±2.44	26.33±2.63	23.69
21	24.10±2.41	23.77±2.38	18.90±1.89	25.57±2.56	28.00±2.80	24.07
28	24.57±2.46	23.10±2.31	18.37±1.84	26.10±2.61	28.67±2.87	24.16
35	24.33±2.43	22.67±2.27	17.77±1.78	26.30±2.63	29.23±2.92	24.06
Mean	24.00	23.51	19.19	25.15	27.43	
LSD at 5%	W = 0.22	D = 0.22	I = 0.48			
LSD at 1%	W = 0.29	D = 0.29	I = 0.64			
			60 days after germination			
7	20.33±2.03	19.90±1.99	19.53±1.95	23.77±2.38	24.33±2.43	21.57
14	21.00±2.10	20.43±2.04	18.80±1.88	23.90±2.39	26.67±2.67	22.16
21	21.00±2.10	20.77±2.08	17.33±1.73	24.77±2.48	27.90±2.79	22.35
28	21.43±2.14	21.33±2.13	16.77±1.68	25.67±2.57	29.67±2.97	22.97
35	23.23±2.32	21.77±2.18	16.33±1.63	27.33±2.73	31.77±3.18	24.09
Mean	21.40	20.84	17.75	25.09	28.07	
LSD at 5%	W = 0.29	D = 0.29	I = 0.65			
LSD at 1%	W = 0.38	D = 0.38	I = 0.86			

Mean ± S.D.

$W_1 - W_5$ = Watering intervals; W_1 = Daily watering, W_2 = Alternate days watering, W_3 = 3 days interval, W_4 = 5 days interval, W_5 = 10 days intervals.

W = Watering intervals; D = Days after treatment; I = Interaction; NS = Non significant

Stomata number = per cm^2 area

Table 39. Stomatal index at abaxial surface of selected invasive plants treated with varying water regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 38).

Days after Treatment	Treatments (watering intervals) W_1	W_2	W_3	W_4	W_5	Mean
			Mirabilis jalapa			
			30 days after germination			
7	29.54±2.27	25.90±1.72	18.86±1.92	19.38±0.64	20.92±2.13	22.92
14	30.35±1.08	24.96±1.53	19.04±0.45	20.18±0.88	21.67±1.12	23.24
21	27.43±1.25	27.11±1.53	19.74±1.80	21.37±4.30	24.06±0.71	23.94
28	31.10±1.99	26.95±1.22	20.75±0.91	21.87±1.60	25.41±1.62	25.22
35	30.06±1.08	27.30±1.33	20.91±1.58	24.07±1.53	25.87±1.74	25.64
Mean	29.70	26.44	19.86	21.37	23.59	
LSD at 5%	W = 1.02	D = 1.02	I = NS			
LSD at 1%	W = 1.35	D = 1.35	I = NS			
			60 days after germination			
7	26.70±26.70	27.09±27.09	19.88±19.88	19.89±19.89	21.52±21.52	23.02
14	26.29±26.29	28.38±28.38	22.18±22.18	21.48±21.48	22.86±22.86	24.24
21	29.06±29.06	26.78±26.78	22.18±22.18	22.22±22.22	25.70±25.70	25.19
28	27.77±27.77	27.38±27.38	22.68±22.68	24.11±24.11	26.05±26.05	25.60
35	29.82±29.82	27.60±27.60	23.52±23.52	25.46±25.46	26.12±26.12	26.50
Mean	27.93	27.45	22.09	22.63	24.45	
LSD at 5%	W = 2.06	D = 2.06	I = NS			
LSD at 1%	W = 2.74	D = 2.74	I = NS			
			Ruellia tuberosa			
			30 days after germination			
7	38.55±0.80	35.59±1.08	31.93±1.49	28.74±1.44	29.13±1.68	32.79
14	38.19±0.43	36.24±0.69	29.74±1.19	29.01±1.45	29.19±0.99	32.47
21	38.87±1.17	36.65±1.20	28.56±1.82	30.78±1.79	31.03±1.44	33.18
28	41.72±2.41	37.74±1.19	26.84±2.37	31.35±1.08	33.47±2.00	34.22
35	41.76±1.42	38.87±1.42	27.74±1.45	31.60±1.84	33.56±1.10	34.71
Mean	39.82	37.02	28.96	30.30	31.28	
LSD at 5%	W = 1.06	D = 1.06	I = 2.36			
LSD at 1%	W = 1.41	D = 1.41	I = 3.14			
			60 days after germination			
7	40.08±0.63	33.88±0.76	30.75±0.67	31.55±1.55	30.47±1.95	33.35
14	41.11±1.49	35.71±1.07	27.74±0.36	31.60±1.76	32.79±2.01	33.79
21	41.27±2.34	38.45±1.05	25.68±1.16	33.27±1.83	34.08±2.24	34.55
28	41.61±1.30	39.55±1.03	24.46±2.05	33.79±1.79	35.35±1.65	34.95
35	43.35±1.56	40.08±0.58	23.79±1.76	34.26±2.57	35.52±0.95	35.40
Mean	41.48	37.53	26.48	32.89	33.64	
LSD at 5%	W = 1.13	D = 1.13	I = 2.52			
LSD at 1%	W = 1.50	D = 1.50	I = 3.35			

Mean ± S.D.

$W_1 - W_5$ = Watering intervals; W_1 = Daily watering, W_2 = Alternate days watering, W_3 = 3 days interval, W_4 = 5 days interval, W_5 = 10 days intervals.

W = Watering intervals; D = Days after treatment; I = Interaction; NS = Non significant

Table 40. Proportion of leaf tissue area of selected invasive plants treated with varying water regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 39).

Leaf tissues	Treatments (watering intervals) W1	W2	W3	W4	W5	LSD at 5%	LSD at 1%
			Mirabilis jalapa				
			30 days after germination				
Dermal system	1039.0±93.5	1054.7±94.9	1102.6±99.2	1137.1±102.3	1292.4±116.3	17.16	24.96
Palisade parenchyma	1814.7±163.3	1826.7±164.4	1889.6±170.1	2660.5±239.5	2850.1±256.5	85.51	124.41
Spongy parenchyma	2157.8±194.2	2140.7±192.7	3125.6±281.3	3029.8±272.7	3599.7±324.0	108.67	158.11
Vascular area	103.2±9.3	102.3±9.2	152.4±13.7	203.2±18.3	314.3±28.3	14.96	21.76
Total leaf tissue area	5114.7±460.4	5124.4±458.2	6270.2±564.4	7030.6±632.8	8056.5±725.2	215.78	313.94
			60 days after germination				
Dermal system	1063.4±95.7	1087.4±97.9	1112.4±100.1	1153.3±103.8	1303.6±117.3	16.13	23.47
Palisade parenchyma	1849.3±166.5	1893.1±170.4	1917.5±172.6	2403.2±216.3	2905.3±261.5	77.45	112.69
Spongy parenchyma	2173.1±195.6	2036.3±183.3	3002.6±270.3	3104.3±279.4	3605.7±324.5	112.34	163.45
Vascular area	101.7±9.2	103.1±9.3	155.4±14.0	201.3±18.1	305.7±27.5	14.35	20.88
Total leaf tissue area	5187.5±466.9	5119.8±460.8	6187.9±557.0	6862.0±617.6	8120.2±730.9	212.21	308.75
			Ruellia tuberosa				
			30 days after germination				
Dermal system	1091.3±98.2	1108.2±99.7	1117.5±100.6	1140.1±102.6	1330.2±119.7	16.63	24.20
Palisade parenchyma	1839.5±165.6	1819.3±163.7	1989.8±179.1	2280.3±205.3	2660.0±239.4	60.12	87.47
Spongy parenchyma	1925.3±173.3	1946.0±175.2	1896.0±170.7	1747.6±157.3	1350.1±121.5	42.18	61.37
Vascular area	50.7±4.6	50.0±4.5	101.6±9.1	149.1±13.4	199.9±18.0	10.98	15.98
Total leaf tissue area	4906.8±417.7	4923.5±443.2	5104.9±462.5	5317.1±478.9	5540.2±496.0	57.52	83.68
			60 days after germination				
Dermal system	1107.2±99.7	1079.5±97.2	1147.1±103.2	1205.7±108.5	1304.4±117.4	15.16	22.05
Palisade parenchyma	1803.1±162.3	1852.1±166.7	2055.7±185.0	2206.0±198.6	2539.8±228.6	50.55	73.54
Spongy parenchyma	1943.1±174.9	1913.4±172.2	1862.8±167.7	1703.2±153.3	1469.4±132.3	33.21	48.31
Vascular area	55.1±5.0	53.6±4.8	95.2±8.6	145.7±13.1	197.1±17.7	10.47	15.24
Total leaf tissue area	4908.5±441.8	4898.6±440.9	5160.8±464.5	5260.6±473.5	5510.7±496.0	43.54	63.35

Mean ± S.D. (values show area of each tissue system in μm^2 in a vertical section of leaf)

$W_1 - W_5$ = Watering intervals; W_1 = Daily watering, W_2 = Alternate days watering, W_3 = 3 days interval, W_4 = 5 days interval, W_5 = 10 days intervals (plants highly wilted).

W = Watering intervals; D = Days after treatment; I = Interaction

Table 41. Floral bud plant^{-1} of selected invasive plants treated with varying water regimes at two stages of growth (30 and 60 days after germination (presented as Figure 40).

Days after treatment	Treatments (watering intervals)					
	W_1	W_2	W_3	W_4	W_5	Mean
			Mirabilis jalapa			
			30 days after germination			
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
14	8.67±1.53	7.33±2.08	3.67±1.53	0.00±0.00	0.00±0.00	3.93
21	12.33±3.06	9.33±2.08	5.33±1.53	0.00±0.00	0.00±0.00	5.40
28	12.67±3.06	13.33±2.08	8.33±2.08	0.00±0.00	0.00±0.00	6.87
35	15.33±3.06	14.67±2.52	10.33±2.31	0.00±0.00	0.00±0.00	8.07
Mean	9.80	8.93	5.53	0.00	0.00	
LSD at 5%	W = 1.19	D = 1.19	I = 2.65			
LSD at 1%	W = 1.58	D = 1.58	I = 3.53			
			60 days after germination			
7	14.67±2.52	15.67±1.53	14.33±1.53	14.00±1.73	10.67±2.08	13.87
14	14.33±2.08	16.67±2.08	14.67±2.52	12.33±3.21	7.33±1.53	13.07
21	18.67±3.06	19.33±1.15	15.67±2.08	11.67±3.51	4.67±2.08	14.00
28	19.33±1.15	20.67±1.53	15.33±1.53	11.33±1.53	2.67±1.53	13.87
35	19.67±3.06	20.33±4.51	16.33±1.53	10.67±2.89	0.00±0.00	13.40
Mean	17.33	18.53	15.27	12.00	5.07	
LSD at 5%	W = 1.40	D = NS	I = 3.14			
LSD at 1%	W = 1.87	D = NS	I = 4.17			
			Ruellia tuberosa			
			30 days after germination			
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
14	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
21	2.67±1.15	1.67±1.53	0.33±0.58	0.00±0.00	0.00±0.00	0.93
28	3.33±1.53	2.33±2.31	1.67±0.58	0.33±0.58	0.00±0.00	1.53
35	3.67±2.08	3.67±2.08	2.33±1.53	1.33±0.58	0.00±0.00	2.20
Mean	1.93	1.53	0.87	0.33	0.00	
LSD at 5%	W = 0.59	D = 0.59	I = 1.32			
LSD at 1%	W = 0.78	D = 0.78	I = 1.75			
			60 days after germination			
7	2.67±1.78	3.33±2.22	3.67±2.45	3.67±2.45	3.33±2.22	3.33
14	4.67±3.11	4.67±3.11	4.33±2.89	3.33±2.22	3.67±2.45	4.13
21	6.33±4.22	6.33±4.22	5.33±3.55	3.33±2.22	2.33±1.55	4.73
28	5.67±3.78	6.67±4.45	5.33±3.55	2.67±1.78	2.33±1.55	4.53
35	7.33±4.89	7.67±5.11	6.33±4.22	2.33±1.55	1.33±0.89	5.00
Mean	5.33	5.73	5.00	3.07	2.60	
LSD at 5%	W = 0.83	D = 0.83	I = 1.87			
LSD at 1%	W = 1.11	D = 1.11	I = 2.48			

Mean ± S.D.

$W_1 - W_5$ = Watering intervals; W_1 = Daily watering, W_2 = Alternate days watering, W_3 = 3 days interval, W_4 = 5 days interval, W_5 = 10 days intervals.

W = Watering intervals; D = Days after treatment; I = Interaction; NS = Non significant

Table 42. Flower plant^{-1} of selected invasive plants treated with varying water regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 41).

Days after treatment	Treatments (watering intervals)					
	W_1	**W_2**	**W_3**	**W_4**	**W_5**	**Mean**
			Mirabilis jalapa			
			30 days after germination			
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
14	1.33±0.58	1.67±1.15	0.00±0.00	0.00±0.00	0.00±0.00	0.60
21	2.67±1.15	3.33±1.15	1.67±0.58	0.00±0.00	0.00±0.00	1.53
28	4.67±1.53	5.33±2.52	2.33±1.53	0.00±0.00	0.00±0.00	2.47
35	6.67±2.08	7.33±1.53	3.33±1.53	0.00±0.00	0.00±0.00	3.47
Mean	3.07	3.53	1.47	0.00	0.00	
LSD at 5%	W = 0.64	D = 0.64	I = 1.43			
LSD at 1%	W = 0.85	D = 0.85	I = 1.90			
			60 days after germination			
7	8.67±3.06	8.33±1.15	7.67±1.53	7.33±2.08	6.67±1.53	7.73
14	11.67±1.53	13.67±2.08	10.33±1.15	6.67±0.58	4.33±1.53	9.33
21	14.33±4.04	15.67±1.15	9.67±1.53	5.67±2.52	1.67±0.58	9.40
28	16.67±2.08	15.33±2.52	10.67±3.51	5.33±1.53	0.67±0.58	9.73
35	17.67±2.08	16.33±2.52	12.33±2.31	4.67±1.53	0.00±0.00	10.20
Mean	13.80	13.87	10.13	5.93	2.67	
LSD at 5%	W = 1.30	D = 1.30	I = 2.92			
LSD at 1%	W = 1.73	D = 1.73	I = 3.88			
			Ruellia tuberosa			
			30 days after germination			
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
14	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
21	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
28	1.67±1.53	0.67±0.58	0.33±0.58	0.00±0.00	0.00±0.00	0.53
35	2.33±1.15	2.67±0.58	1.33±1.15	0.00±0.00	0.00±0.00	1.27
Mean	0.80	0.67	0.33	0.00	0.00	
LSD at 5%	W = 0.34	D = 0.34	I = 0.76			
LSD at 1%	W = 0.45	D = 0.45	I = 1.02			
			60 days after germination			
7	2.33±1.17	1.67±0.84	2.33±1.17	2.33±1.17	1.67±0.84	2.07
14	3.33±1.67	2.67±1.34	2.67±1.34	1.67±0.84	1.33±0.67	2.33
21	2.67±1.34	3.33±1.67	2.33±1.17	0.67±0.34	0.67±0.34	1.93
28	3.67±1.84	2.67±1.34	2.33±1.17	0.33±0.17	0.00±0.00	1.80
35	3.33±1.67	3.67±1.84	2.67±1.34	0.00±0.00	0.00±0.00	1.93
Mean	3.07	2.80	2.47	1.00	0.73	
LSD at 5%	W = 0.42	D = NS	I = 0.93			
LSD at 1%	W = 0.56	D = NS	I = 1.24			

Mean ± S.D.

$W_1 - W_5$ = Watering intervals; W_1 = Daily watering, W_2 = Alternate days watering, W_3 = 3 days interval, W_4 = 5 days interval, W_5 = 10 days intervals.

W = Watering intervals; D = Days after treatment; I = Interaction; NS = Non significant

Table 43. Fruit plant^{-1} of selected invasive plants treated with varying water regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 42).

Days after treatment	Treatments (watering intervals)					
	W_1	W_2	W_3	W_4	W_5	Mean
			Mirabilis jalapa			
			30 days after germination			
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
14	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
21	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
28	1.33±0.58	0.67±0.58	0.33±0.58	0.00±0.00	0.00±0.00	0.47
35	2.33±0.58	1.67±0.58	0.67±0.58	0.00±0.00	0.00±0.00	0.93
Mean	0.73	0.47	0.20	0.00	0.00	
LSD at 5%	W = 0.20	D = 0.20	I = 0.45			
LSD at 1%	W = 0.27	D = 0.27	I = 0.60			
			60 days after germination			
7	1.33±0.58	1.67±0.58	1.67±1.15	1.67±0.58	1.33±0.58	1.53
14	2.67±0.58	2.00±1.00	1.67±0.58	1.67±1.15	0.67±0.58	1.73
21	2.33±0.58	2.67±1.15	2.33±1.15	1.33±0.58	0.33±0.58	1.80
28	3.33±1.53	3.33±0.58	2.33±0.58	1.33±0.58	0.00±0.00	2.07
35	3.67±1.53	3.33±1.53	2.67±1.15	1.00±1.00	0.00±0.00	2.13
Mean	2.67	2.60	2.13	1.40	0.47	
LSD at 5%	W = 0.63	D = NS	I = NS			
LSD at 1%	W = 0.84	D = NS	I = NS			
			Ruellia tuberosa			
			30 days after germination			
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
14	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
21	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
28	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
35	1.67±0.58	1.33±0.58	0.33±0.58	0.00±0.00	0.00±0.00	0.67
Mean	0.33	0.27	0.07	0.00	0.00	
LSD at 5%	W = 0.14	D = 0.14	I = 0.31			
LSD at 1%	W = 0.18	D = 0.18	I = 0.41			
			60 days after germination			
7	2.33±0.58	1.33±0.58	1.67±0.58	1.33±0.58	1.67±1.15	1.67
14	2.67±1.53	2.33±1.53	1.33±0.58	1.33±0.58	1.33±1.15	1.80
21	2.67±0.58	3.33±1.53	1.67±1.15	1.33±0.58	1.00±1.00	2.00
28	3.33±1.15	2.67±1.53	1.67±1.15	1.00±1.00	0.67±1.15	1.87
35	3.33±2.31	3.33±0.58	2.33±1.53	0.33±0.58	0.00±0.00	1.87
Mean	2.87	2.60	1.73	1.07	0.93	
LSD at 5%	W = 0.67	D = NS	I = NS			
LSD at 1%	W = 0.89	D = NS	I = NS			

Mean ± S.D.

$W_1 - W_5$ = Watering intervals; W_1 = Daily watering, W_2 = Alternate days watering, W_3 = 3 days interval, W_4 = 5 days interval, W_5 = 10 days intervals.

W = Watering intervals; D = Days after treatment; I = Interaction; NS = Non significant

Table 44. Seed output plant^{-1} of selected invasive plants treated with varying water regimes at growth stage (60 days after germination) (presented as Figure 43).

Days after treatment	Treatments (watering intervals)					
	W_1	W_2	W_3	W_4	W_5	Mean
			Mirabilis jalapa			
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	1.33±0.58	0.27
14	0.00±0.00	0.00±0.00	0.00±0.00	1.67±0.58	1.33±0.58	0.60
21	0.00±0.00	0.00±0.00	0.00±0.00	1.33±0.58	0.33±0.58	0.33
28	4.00±1.73	3.33±1.15	2.67±1.15	0.67±1.15	0.00±0.00	2.13
35	4.33±1.15	3.67±2.08	2.67±0.58	0.00±0.00	0.00±0.00	2.13
Mean	1.67	1.40	1.07	0.73	0.60	
LSD at 5%	W = 0.54	D = 0.54	I = 1.21			
LSD at 1%	W = 0.72	D = 0.72	I = 1.61			
			Ruellia tuberosa			
7	71.46±3.57	42.12±2.11	50.65±2.53	43.00±2.15	50.65±2.53	51.58
14	75.64±3.78	66.80±3.34	39.01±1.95	35.02±1.75	27.04±1.35	48.70
21	83.65±4.18	91.01±4.55	47.31±2.37	35.47±1.77	18.33±0.92	55.15
28	102.13±5.11	77.43±3.87	47.88±2.39	24.33±1.22	13.85±0.69	53.12
35	107.66±5.38	108.79±5.44	61.35±3.07	7.37±0.37	0.00±0.00	57.03
Mean	88.11	77.23	49.24	29.04	21.97	
LSD at 5%	W = 1.13	D = 1.13	I = 2.52			
LSD at 1%	W = 1.50	D = 1.50	I = 3.35			

Mean ± S.D.

$W_1 - W_5$ = Watering intervals; W_1 = Daily watering, W_2 = Alternate days watering, W_3 = 3 days interval, W_4 = 5 days interval, W_5 = 10 days intervals.

W = Watering intervals; D = Days after treatment; I = Interaction; NS = Non significant

Table 45. Plant height (cm) of selected invasive plants treated with varying light regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 44).

Days after treatment	Treatments (Luminance stage)			
	Open (100-90%)	**Partially shaded (85-70%)**	**Shaded (35-25%)**	**Mean**
		Mirabilis jalapa 30 days after germination		
	(1550±21.8 Lux)	**(1249±56.16 Lux)**	**(451±51.4 Lux)**	
7	15.92±2.83	16.54±1.62	17.01±3.84	16.49
14	16.75±2.07	18.38±2.85	19.73±1.57	18.29
21	21.14±2.23	25.17±5.07	24.34±8.45	23.55
28	29.38±4.99	29.46±1.78	31.90±2.62	30.25
35	29.29±3.17	32.04±3.14	36.29±6.79	32.54
Mean	22.50	24.32	25.85	
LSD at 5%	L = 1.26	D = 0.98	I = 2.19	
LSD at 1%	L = 1.70	D = 1.32	I = 2.95	
		60 days after germination		
	(1518±45.5 Lux)	**(1236±65.8 Lux)**	**(466±42.5 Lux)**	
7	31.08±2.26	32.08±4.10	33.24±2.54	32.13
14	34.39±2.12	34.36±4.64	35.20±2.90	34.65
21	36.67±2.17	36.59±5.10	35.53±2.64	36.26
28	38.59±2.29	38.28±2.48	39.48±3.55	38.78
35	39.68±1.32	39.11±3.04	41.59±2.38	40.13
Mean	36.08	36.08	37.01	
LSD at 5%	L = NS	D = 2.06	I = NS	
LSD at 1%	L = NS	D = 2.78	I = NS	
		Ruellia tuberosa 30 days after germination		
	(1503±45.6 Lux)	**(1229±61.6 Lux)**	**(461±35.4 Lux)**	
7	16.35±0.95	15.32±0.83	15.65±0.65	15.77
14	17.42±1.00	16.78±0.28	16.75±0.63	16.98
21	18.95±1.12	19.47±1.35	17.07±1.01	18.50
28	21.08±0.63	20.95±1.58	17.29±1.44	19.77
35	22.95±0.72	21.54±1.15	18.86±1.90	21.11
Mean	19.35	18.81	17.12	
LSD at 5%	L = 1.06	D = 0.82	I = 1.83	
LSD at 1%	L = 1.42	D = 1.10	I = 2.47	
		60 days after germination		
	(1498±47.4 Lux)	**(1195±57.7 Lux)**	**(451±44.2 Lux)**	
7	22.97±0.28	23.76±4.77	24.14±3.43	23.62
14	24.56±2.41	27.17±4.15	25.78±3.23	25.84
21	28.34±0.90	33.13±2.10	26.62±2.79	29.36
28	31.15±0.46	35.07±2.95	28.93±2.80	31.72
35	32.54±0.58	35.17±2.88	29.59±3.57	32.43
Mean	27.91	30.86	27.01	
LSD at 5%	L = 1.27	D = 0.98	I = 2.20	
LSD at 1%	L = 1.71	D = 1.32	I = 2.96	

Mean ± S.D.

L = Light intensity; D = Days after treatment; I = Interaction; NS = Non significant

Table 46. Leaf $plant^{-1}$ of selected invasive plants treated with varying light regimes at two stages of growth (30 and 60 days from germination) (presented as Figure 45).

Days after treatment	Treatments (Luminance stage) Open (100-90%)	Partially shaded (85-70%)	Shaded (35-25%)	Mean
		Mirabilis jalapa		
		30 days after germination		
	(1550±21.8 Lux)	**(1249±56.16 Lux)**	**(451±51.4 Lux)**	
7	24.67±5.03	21.33±3.79	18.33±4.16	21.44
14	25.33±3.51	26.33±4.16	23.67±3.06	25.11
21	28.33±2.08	27.67±4.51	25.33±5.03	27.11
28	33.67±2.31	32.33±4.16	29.67±2.52	31.89
35	36.33±1.53	33.67±2.89	34.67±4.51	34.89
Mean	29.67	28.27	26.33	
LSD at 5%	L = 1.22	D = 0.94	I = 2.11	
LSD at 1%	L = 1.64	D = 1.27	I = 2.84	
		60 days after germination		
	(1518±45.5 Lux)	**(1236±65.8 Lux)**	**(466±42.5 Lux)**	
7	37.33±2.08	36.67±3.79	35.67±2.52	33.22
14	39.67±5.69	37.67±2.08	36.67±9.07	38.00
21	42.67±2.52	37.33±1.53	36.33±4.04	38.78
28	46.33±2.08	39.33±5.13	37.33±4.93	41.00
35	48.33±4.04	40.67±4.62	38.67±1.53	42.56
Mean	42.87	38.33	36.93	
LSD at 5%	L = 2.30	D = 1.78	I = 3.98	
LSD at 1%	L = 3.10	D = 2.40	I = 5.36	
		Ruellia tuberosa		
		30 days after germination		
	(1503±45.6 Lux)	**(1229±61.6 Lux)**	**(461±35.4 Lux)**	
7	8.33±1.53	9.33±1.53	6.67±2.52	8.11
14	9.67±3.06	11.33±2.31	8.67±1.15	9.89
21	11.67±2.89	12.67±1.53	9.33±1.53	11.22
28	13.33±3.21	15.33±3.06	12.67±2.52	13.78
35	14.33±3.06	16.67±1.53	12.67±2.08	14.56
Mean	11.47	13.07	10.00	
LSD at 5%	L = 0.44	D = 0.34	I = 0.76	
LSD at 1%	L = 0.59	D = 0.46	I = 1.02	
		60 days after germination		
	(1498±47.4 Lux)	**(1195±57.7 Lux)**	**(451±44.2 Lux)**	
7	14.67±2.08	11.33±3.21	12.67±2.52	12.89
14	15.33±2.31	13.33±3.51	14.67±2.52	14.44
21	18.67±5.51	15.67±2.08	16.33±3.51	16.89
28	22.67±3.21	18.67±4.16	16.67±2.31	19.33
35	23.33±2.52	22.67±4.62	16.67±2.08	20.89
Mean	18.93	16.33	15.40	
LSD at 5%	L = 1.71	D = 1.33	I = 2.97	
LSD at 1%	L = 2.31	D = 1.79	I = 4.00	

Mean ± S.D.

L = Light intensity; D = Days after treatment; I = Interaction; NS = Non significant

Table 47. Leaf area expansion (cm^2) of selected invasive plants treated with varying light regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 46).

Days after treatment	Treatments (Luminance stage)			
	Open (100-90%)	**Partially shaded (85-70%)**	**Shaded (35-25%)**	**Mean**
		Mirabilis jalapa		
		30 days after germination		
	(1550±21.8 Lux)	**(1249±56.16 Lux)**	**(451±51.4 Lux)**	
7	4.85±1.21	6.68±1.67	5.75±1.44	5.76
14	17.38±4.35	15.48±3.87	13.68±3.42	15.51
21	23.95±5.99	20.08±5.02	22.75±5.69	22.26
28	26.68±6.67	24.49±6.12	27.25±6.81	26.14
35	29.34±7.34	28.17±7.04	37.50±9.38	31.67
Mean	20.44	18.98	21.39	
LSD at 5%	L = 2.22	D = 1.72	I = 3.85	
LSD at 1%	L = 2.99	D = 2.32	I = 5.18	
		60 days after germination		
	(1518±45.5 Lux)	**(1236±65.8 Lux)**	**(466±42.5 Lux)**	
7	8.05±1.78	6.36±1.24	7.39±1.80	7.27
14	19.05±2.08	22.34±3.88	20.08±2.71	20.49
21	28.36±2.14	27.49±3.62	36.64±6.80	30.83
28	33.37±2.93	33.25±6.27	40.33±5.62	35.65
35	38.00±3.22	37.27±2.82	44.17±7.34	39.81
Mean	25.37	25.34	29.72	
LSD at 5%	L = 2.90	D = 2.24	I = 5.02	
LSD at 1%	L = 3.90	D = 3.02	I = 6.76	
		Ruellia tuberosa		
		30 days after germination		
	(1503±45.6 Lux)	**(1229±61.6 Lux)**	**(461±35.4 Lux)**	
7	3.49±0.61	2.98±1.02	3.06±0.91	3.18
14	10.15±0.38	10.48±2.55	6.32±2.27	8.98
21	11.36±0.72	17.35±1.58	9.27±1.65	12.66
28	19.95±0.96	19.43±1.47	12.61±2.16	17.33
35	21.17±1.05	22.17±1.91	14.33±1.06	19.22
Mean	13.22	14.48	9.12	
LSD at 5%	L = 1.38	D = 1.07	I = 2.40	
LSD at 1%	L = 1.86	D = 1.44	I = 3.23	
		60 days after germination		
	(1498±47.4 Lux)	**(1195±57.7 Lux)**	**(451±44.2 Lux)**	
7	3.38±0.76	3.34±0.45	2.25±0.80	2.99
14	7.59±1.23	6.43±1.87	3.64±0.63	5.89
21	15.39±1.85	11.43±1.82	7.68±1.76	11.50
28	20.78±1.78	16.35±2.80	10.34±2.92	15.82
35	23.47±2.98	21.27±3.46	12.35±3.56	19.03
Mean	14.12	11.76	7.25	
LSD at 5%	L = 2.05	D = 1.58	I = 3.54	
LSD at 1%	L = 2.75	D = 2.13	I = 4.77	

Mean ± S.D.

L = Light intensity; D = Days after treatment; I = Interaction; NS = Non significant

Table 48. Relative water content (%) of selected invasive plants treated with varying light regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 47).

Days after treatment	Treatments (Luminance stage) Open (100-90%)	Partially shaded (85-70%)	Shaded (35-25%)	Mean
		Mirabilis jalapa		
		30 days after germination		
	(1550±21.8 Lux)	**(1249±56.16 Lux)**	**(451±51.4 Lux)**	
7	88.54±2.06	88.83±1.08	88.98±0.35	88.78
14	88.68±0.57	89.04±2.03	89.37±1.16	89.03
21	87.39±2.50	88.43±2.47	89.98±2.82	88.60
28	86.65±1.93	87.24±1.31	91.42±1.70	88.44
35	88.03±1.20	89.47±2.44	91.38±2.64	89.63
Mean	87.86	88.60	90.23	
LSD at 5%	L = 1.79	D = NS	I = NS	
LSD at 1%	L = 2.42	D = NS	I = NS	
		60 days after germination		
	(1518±45.5 Lux)	**(1236±65.8 Lux)**	**(466±42.5 Lux)**	
7	88.83±3.30	87.94±1.49	88.67±5.07	88.48
14	88.04±1.68	88.04±0.37	88.42±1.70	88.17
21	86.03±2.21	87.59±1.53	88.93±3.61	87.52
28	85.95±2.33	86.31±2.75	88.74±1.12	87.00
35	86.15±4.97	86.36±3.99	88.89±2.46	87.13
Mean	87.00	87.25	88.73	
LSD at 5%	L = NS	D = NS	I = NS	
LSD at 1%	L = NS	D = NS	I = NS	
		Ruellia tuberosa		
		30 days after germination		
	(1503±45.6 Lux)	**(1229±61.6 Lux)**	**(461±35.4 Lux)**	
7	88.39±0.60	90.98±2.12	89.13±0.53	89.50
14	88.85±1.16	89.76±2.05	88.85±2.41	89.15
21	87.76±0.27	89.88±2.72	89.39±3.70	89.01
28	86.42±1.86	88.49±1.81	89.84±1.56	88.25
35	86.21±0.49	88.03±1.47	90.05±2.73	88.10
Mean	87.53	89.43	89.45	
LSD at 5%	L = 1.73	D = NS	I = NS	
LSD at 1%	L = 2.33	D = NS	I = NS	
		60 days after germination		
	(1498±47.4 Lux)	**(1195±57.7 Lux)**	**(451±44.2 Lux)**	
7	89.32±0.52	87.98±2.15	88.15±2.76	88.48
14	86.59±0.21	88.64±2.83	89.32±2.91	88.18
21	88.35±0.39	87.37±1.13	89.39±3.62	88.37
28	85.34±0.32	87.40±2.00	90.54±2.02	87.76
35	86.07±2.10	87.21±1.81	89.27±2.37	87.52
Mean	87.13	87.72	89.33	
LSD at 5%	L = 1.88	D = NS	I = NS	
LSD at 1%	L = 2.53	D = NS	I = NS	

Mean ± S.D.

L = Light intensity; D = Days after treatment; I = Interaction; NS = Non significant

Table 49. Chlorophyll a (mg g^{-1} fresh weight) of selected invasive plants treated with varying light regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 48).

Days after treatment	Treatments (Luminance stage)			
	Open (100-90%)	**Partially shaded (85-70%)**	**Shaded (35-25%)**	**Mean**
	Mirabilis jalapa 30 days after germination			
	(1550±21.8 Lux)	**(1249±56.16 Lux)**	**(451±51.4 Lux)**	
7	0.889±0.025	0.873±0.025	0.869±0.025	0.877
14	0.895±0.026	0.886±0.025	0.879±0.025	0.887
21	0.852±0.024	0.872±0.025	0.881±0.025	0.868
28	0.865±0.025	0.864±0.025	0.876±0.025	0.868
35	0.885±0.025	0.883±0.025	0.902±0.026	0.890
Mean	0.877	0.876	0.881	
LSD at 5%	L = NS	D = NS	I = NS	
LSD at 1%	L = NS	D = NS	I = NS	
	60 days after germination			
	(1518±45.5 Lux)	**(1236±65.8 Lux)**	**(466±42.5 Lux)**	
7	0.865±0.017	0.884±0.018	0.864±0.017	0.871
14	0.882±0.018	0.868±0.017	0.892±0.018	0.881
21	0.852±0.017	0.863±0.017	0.883±0.018	0.866
28	0.898±0.018	0.892±0.018	0.896±0.018	0.895
35	0.917±0.018	0.916±0.018	0.944±0.019	0.926
Mean	0.883	0.885	0.896	
LSD at 5%	L = NS	D = NS	I = NS	
LSD at 1%	L = NS	D = NS	I = NS	
	Ruellia tuberose 30 days after germination			
	(1503±45.6 Lux)	**(1229±61.6 Lux)**	**(461±35.4 Lux)**	
7	0.505±0.014	0.521±0.015	0.534±0.015	0.520
14	0.549±0.016	0.563±0.016	0.589±0.017	0.567
21	0.563±0.016	0.586±0.017	0.603±0.017	0.584
28	0.587±0.017	0.582±0.017	0.638±0.018	0.602
35	0.593±0.017	0.575±0.016	0.634±0.018	0.601
Mean	0.559	0.565	0.600	
LSD at 5%	L = NS	D = NS	I = NS	
LSD at 1%	L = NS	D = NS	I = NS	
	60 days after germination			
	(1498±47.4 Lux)	**(1195±57.7 Lux)**	**(451±44.2 Lux)**	
7	0.574±0.028	0.584±0.022	0.603±0.045	0.587
14	0.585±0.011	0.602±0.009	0.634±0.018	0.607
21	0.594±0.037	0.595±0.038	0.616±0.012	0.602
28	0.608±0.034	0.611±0.047	0.627±0.007	0.615
35	0.612±0.014	0.626±0.029	0.631±0.034	0.623
Mean	0.595	0.604	0.622	
LSD at 5%	L = 0.026	D = NS	I = NS	
LSD at 1%	L = 0.035	D = NS	I = NS	

Mean ± S.D.

L = Light intensity; D = Days after treatment; I = Interaction; NS = Non significant

Table 50. Chlorophyll b (mg g^{-1} fresh weight) of selected invasive plants treated with varying light regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 49).

Days after treatment	Treatments (Luminance stage)			
	Open (100-90%)	**Partially shaded (85-70%)**	**Shaded (35-25%)**	**Mean**
		Mirabilis jalapa		
		30 days after germination		
	(1550±21.8 Lux)	**(1249±56.16 Lux)**	**(451±51.4 Lux)**	
7	0.343±0.033	0.364±0.017	0.359±0.045	0.355
14	0.362±0.024	0.381±0.033	0.365±0.009	0.369
21	0.381±0.015	0.376±0.034	0.382±0.011	0.380
28	0.389±0.031	0.388±0.033	0.397±0.023	0.391
35	0.384±0.043	0.394±0.017	0.402±0.040	0.393
Mean	0.372	0.381	0.381	
LSD at 5%	L = 0.010	D = 0.008	I = NS	
LSD at 1%	L = 0.014	D = 0.011	I = NS	
		60 days after germination		
	(1518±45.5 Lux)	**(1236±65.8 Lux)**	**(466±42.5 Lux)**	
7	0.397±0.027	0.386±0.009	0.365±0.026	0.383
14	0.382±0.033	0.392±0.017	0.372±0.015	0.382
21	0.380±0.014	0.388±0.021	0.396±0.012	0.388
28	0.396±0.031	0.392±0.020	0.418±0.029	0.402
35	0.398±0.017	0.398±0.011	0.436±0.024	0.411
Mean	0.391	0.391	0.397	
LSD at 5%	L = NS	D = 0.015	I = NS	
LSD at 1%	L = NS	D = 0.020	I = NS	
		Ruellia tuberosa		
		30 days after germination		
	(1503±45.6 Lux)	**(1229±61.6 Lux)**	**(461±35.4 Lux)**	
7	0.384±0.012	0.317±0.015	0.310±0.025	0.337
14	0.362±0.011	0.363±0.016	0.359±0.045	0.361
21	0.395±0.040	0.396±0.020	0.383±0.030	0.391
28	0.402±0.028	0.404±0.022	0.431±0.017	0.412
35	0.393±0.013	0.437±0.031	0.466±0.027	0.432
Mean	0.387	0.383	0.390	
LSD at 5%	L = NS	D = 0.030	I = NS	
LSD at 1%	L = NS	D = 0.040	I = NS	
		60 days after germination		
	(1498±47.4 Lux)	**(1195±57.7 Lux)**	**(451±44.2 Lux)**	
7	0.385±0.010	0.368±0.018	0.391±0.005	0.381
14	0.392±0.028	0.384±0.023	0.418±0.022	0.398
21	0.389±0.014	0.429±0.009	0.436±0.015	0.418
28	0.406±0.016	0.417±0.011	0.447±0.033	0.423
35	0.413±0.011	0.431±0.008	0.476±0.040	0.440
Mean	0.397	0.406	0.434	
LSD at 5%	L = 0.016	D = 0.013	I = NS	
LSD at 1%	L = 0.022	D = 0.017	I = NS	

Mean ± S.D.

L = Light intensity; D = Days after treatment; I = Interaction; NS = Non significant

Table 51. Total chlorophyll (mg g^{-1} fresh weight) of selected invasive plants treated with varying light regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 50).

Days after treatment	Treatments (Luminance stage)			Mean
	Open (100-90%)	**Partially shaded (85-70%)**	**Shaded (35-25%)**	
		Mirabilis jalapa		
		30 days after germination		
	(1550±21.8 Lux)	**(1249±56.16 Lux)**	**(451±51.4 Lux)**	
7	1.232±0.036	1.237±0.050	1.223±0.045	1.231
14	1.257±0.036	1.267±0.070	1.247±0.011	1.257
21	1.233±0.044	1.248±0.052	1.265±0.041	1.249
28	1.254±0.037	1.252±0.029	1.273±0.059	1.260
35	1.269±0.070	1.277±0.046	1.304±0.056	1.283
Mean	1.249	1.256	1.262	
LSD at 5%	L = NS	D = NS	I = NS	
LSD at 1%	L = NS	D = NS	I = NS	
		60 days after germination		
	(1518±45.5 Lux)	**(1236±65.8 Lux)**	**(466±42.5 Lux)**	
7	1.262±0.032	1.270±0.018	1.246±0.078	1.259
14	1.264±0.012	1.260±0.031	1.264±0.021	1.263
21	1.232±0.040	1.251±0.020	1.279±0.032	1.254
28	1.294±0.012	1.284±0.029	1.314±0.030	1.297
35	1.315±0.024	1.314±0.036	1.380±0.040	1.336
Mean	1.274	1.276	1.297	
LSD at 5%	L = NS	D = 0.025	I = NS	
LSD at 1%	L = NS	D = 0.034	I = NS	
		Ruellia tuberosa		
		30 days after germination		
	(1503±45.6 Lux)	**(1229±61.6 Lux)**	**(461±35.4 Lux)**	
7	0.889±0.010	0.838±0.008	0.844±0.028	0.857
14	0.911±0.068	0.926±0.037	0.948±0.041	0.928
21	0.958±0.046	0.982±0.028	0.986±0.036	0.975
28	0.989±0.030	0.971±0.058	1.069±0.034	1.010
35	0.986±0.030	1.022±0.047	1.086±0.007	1.031
Mean	0.947	0.948	0.987	
LSD at 5%	L = 0.045	D = 0.036	I = NS	
LSD at 1%	L = 0.061	D = 0.049	I = NS	
		60 days after germination		
	(1498±47.4 Lux)	**(1195±57.7 Lux)**	**(451±44.2 Lux)**	
7	0.959±0.026	0.952±0.011	0.953±0.036	0.955
14	0.977±0.021	0.986±0.031	1.052±0.026	1.005
21	0.983±0.023	1.020±0.038	1.052±0.013	1.018
28	1.014±0.050	1.012±0.054	1.074±0.027	1.033
35	1.025±0.025	1.057±0.023	1.107±0.053	1.063
Mean	0.992	1.005	1.048	
LSD at 5%	L = 0.026	D = 0.021	I = NS	
LSD at 1%	L = 0.035	D = 0.028	I = NS	

Mean ± S.D.

L = Light intensity; D = Days after treatment; I = Interaction; NS = Non significant

Table 52. Above ground biomass (g) of selected invasive plants treated with varying light regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 51).

Days after germination	Treatments (Luminance stage)			LSD at	
	Open (100-90%)	Partially shaded (85-70%)	Shaded (35-25%)		
		Mirabilis jalapa		5%	1%
30	(1550±21.8 Lux) 2.35±0.38	(1249±56.16 Lux) 1.94±0.20	(451±51.4 Lux) 1.35±0.37	0.72	1.19
60	(1518±45.5 Lux) 3.38±0.23	(1236±65.8 Lux) 3.04±0.40	(466±42.5 Lux) 2.65±0.25	NS	NS
		Ruellia tuberosa			
30	(1503±45.6 Lux) 2.55±0.48	(1229±61.6 Lux) 1.74±0.30	(461±35.4 Lux) 0.8±0.40	1.01	1.68
60	(1498±47.4 Lux) 4.41±0.68	(1195±57.7 Lux) 2.65±0.41	(451±44.2 Lux) 1.37±0.37	0.99	1.64

Mean ± S.D.
NS = Non significant

Table 53. Stomata number of adaxial surface of selected invasive plants treated with varying light regimes at two stages of growth (30 and 60 days from germination) (presented as Figure 52).

Days after treatment	Treatments (Luminance stage) Open (100-90%)	Partially shaded (85-70%)	Shaded (35-25%)	Mean
		Mirabilis jalapa		
		30 days after germination		
	(1550±21.8 Lux)	(1249±56.16 Lux)	(451±51.4 Lux)	
7	0.00±0.00	0.00±0.00	1.23±0.06	0.41
14	0.00±0.00	0.00±0.00	1.57±0.08	0.52
21	0.00±0.00	0.53±0.03	1.90±0.10	0.81
28	0.00±0.00	0.77±0.04	0.90±0.50	0.56
35	0.00±0.00	1.10±0.05	1.43±0.07	0.84
Mean	0.00	0.48	1.41	
LSD at 5%	L = 0.03	D = 0.03	I = 0.06	
LSD at 1%	L = 0.04	D = 0.03	I = 0.08	
		60 days after germination		
	(1518±45.5 Lux)	(1236±65.8 Lux)	(466±42.5 Lux)	
7	0.00±0.00	0.00±0.00	0.67±0.03	0.22
14	0.00±0.00	0.00±0.00	2.37±0.12	0.79
21	0.00±0.00	0.00±0.00	1.70±0.09	0.57
28	0.00±0.00	0.67±0.03	1.43±0.07	0.70
35	0.00±0.00	1.57±0.08	1.10±0.05	0.89
Mean	0.00	0.45	1.45	
LSD at 5%	L = 0.04	D = 0.03	I = 0.07	
LSD at 1%	L = 0.05	D = 0.04	I = 0.09	
		Ruellia tuberosa		
		30 days after germination		
	(1503±45.6 Lux)	(1229±61.6 Lux)	(461±35.4 Lux)	
7	4.10±0.21	2.90±0.15	1.37±0.07	2.79
14	4.77±0.24	3.77±0.19	2.10±0.11	3.55
21	4.43±0.22	2.50±0.13	1.77±0.09	2.90
28	4.57±0.23	4.77±0.24	1.37±0.07	3.57
35	4.90±0.25	3.10±0.16	1.97±0.10	3.32
Mean	4.55	3.41	1.72	
LSD at 5%	L = 0.06	D = 0.05	I = 0.11	
LSD at 1%	L = 0.09	D = 0.07	I = 0.15	
		60 days after germination		
	(1498±47.4 Lux)	(1195±57.7 Lux)	(451±44.2 Lux)	
7	3.33±0.17	3.10±0.16	2.10±0.11	2.84
14	5.23±0.26	4.37±0.22	2.23±0.11	3.94
21	4.43±0.22	2.87±0.14	2.43±0.12	3.24
28	4.90±0.25	4.57±0.23	2.90±0.15	4.12
35	4.77±0.24	4.57±0.23	2.57±0.13	3.97
Mean	4.53	3.90	2.45	
LSD at 5%	L = 0.05	D = 0.04	I = 0.09	
LSD at 1%	L = 0.07	D = 0.05	I = 0.12	

Mean ± S.D.

L = Light intensity; D = Days after treatment; I = Interaction; NS = Non significant

Table 54. Stomatal index of adaxial surface of selected invasive plants treated with varying light regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 53).

Days after treatment	Treatments (Luminance stage) Open (100-90%)	Partially shaded (85-70%)	Shaded (35-25%)	Mean
		Mirabilis jalapa		
		30 days after germination		
	(1550±21.8 Lux)	**(1249±56.16 Lux)**	**(451±51.4 Lux)**	
7	0.00±0.00	0.00±0.00	4.78±1.46	1.59
14	0.00±0.00	0.00±0.00	4.26±0.99	1.42
21	0.00±0.00	4.21±1.13	4.18±1.04	2.80
28	0.00±0.00	7.31±1.30	5.21±1.02	4.17
35	0.00±0.00	6.98±1.81	5.79±2.15	4.26
Mean	0.00	3.70	4.84	
LSD at 5%	L = 0.96	D = 0.74	I = 1.66	
LSD at 1%	L = 1.29	D = 1.00	I = 2.23	
		60 days after germination		
	(1518±45.5 Lux)	**(1236±65.8 Lux)**	**(466±42.5 Lux)**	
7	0.00±0.00	0.00±0.00	5.26±1.88	1.75
14	0.00±0.00	0.00±0.00	7.39±2.47	2.46
21	0.00±0.00	0.00±0.00	4.26±0.45	1.42
28	0.00±0.00	5.44±1.18	6.18±1.46	3.87
35	0.00±0.00	6.42±2.32	6.26±1.15	4.23
Mean	0.00	2.37	5.87	
LSD at 5%	L = 1.08	D = 0.83	I = 1.87	
LSD at 1%	L = 1.45	D = 1.12	I = 2.51	
		Ruellia tuberosa		
		30 days after germination		
	(1503±45.6 Lux)	**(1229±61.6 Lux)**	**(461±35.4 Lux)**	
7	10.19±0.89	8.78±0.91	10.50±1.25	9.82
14	9.74±1.15	10.57±0.64	8.94±0.79	9.75
21	9.56±0.57	10.02±2.84	8.86±1.84	9.48
28	11.08±0.63	8.97±0.74	9.12±0.99	9.72
35	10.35±0.67	8.39±0.50	8.56±2.49	9.10
Mean	10.18	9.35	9.20	
LSD at 5%	L = 1.05	D = NS	I = NS	
LSD at 1%	L = 1.41	D = NS	I = NS	
		60 days after germination		
	(1498±47.4 Lux)	**(1195±57.7 Lux)**	**(451±44.2 Lux)**	
7	13.42±1.83	10.71±3.62	10.15±0.27	11.43
14	12.79±2.24	11.09±1.36	10.38±2.99	11.42
21	11.59±1.53	10.82±2.33	8.59±1.88	10.33
28	10.46±1.89	10.69±0.52	9.86±2.06	10.34
35	11.29±2.97	11.54±1.10	8.18±1.15	10.34
Mean	11.91	10.97	9.43	
LSD at 5%	L = 1.84	D = NS	I = NS	
LSD at 1%	L = 2.48	D = NS	I = NS	

Mean ± S.D.

L = Light intensity; D = Days after treatment; I = Interaction; NS = Non significant

Table 55. Stomata number of abaxial surface of selected invasive plants treated with varying light regimes at two stages of growth (30 and 60 days from germination) (presented as Figure 54).

Days after treatment	Treatments (Luminance stage)			Mean
	Open (100-90%)	Partially shaded (85-70%)	Shaded (35-25%)	
	Mirabilis jalapa 30 days after germination			
	(1550±21.8 Lux)	(1249±56.16 Lux)	(451±51.4 Lux)	
7	10.90±0.55	11.33±0.57	18.63±0.93	13.62
14	11.10±0.56	16.67±0.83	18.37±0.92	15.38
21	10.67±0.53	18.67±0.93	22.67±1.13	17.34
28	11.33±0.57	15.33±0.77	22.67±1.13	16.44
35	11.57±0.58	16.33±0.82	24.33±1.22	17.41
Mean	11.11	15.67	21.33	
LSD at 5%	L = 0.23	D = 0.18	I = 0.40	
LSD at 1%	L = 0.31	D = 0.24	I = 0.54	
	60 days after germination			
	(1518±45.5 Lux)	(1236±65.8 Lux)	(466±42.5 Lux)	
7	10.43±0.52	14.23±0.71	18.33±0.92	14.33
14	11.43±0.57	16.90±0.84	21.43±1.07	16.59
21	11.10±0.56	16.33±0.82	22.43±1.12	16.62
28	14.33±0.72	17.43±0.87	20.33±1.02	17.36
35	13.77±0.69	18.33±0.92	20.67±1.03	17.59
Mean	12.21	16.64	20.64	
LSD at 5%	L = 0.19	D = 0.14	I = 0.32	
LSD at 1%	L = 0.25	D = 0.19	I = 0.43	
	Ruellia tuberosa 30 days after germination			
	(1503±45.6 Lux)	(1229±61.6 Lux)	(461±35.4 Lux)	
7	27.77±1.39	23.90±1.20	15.43±0.77	22.37
14	24.47±1.22	24.90±1.25	14.23±0.71	21.20
21	26.67±1.33	22.23±1.11	17.90±0.90	22.27
28	23.43±1.17	23.23±1.16	18.77±0.94	21.81
35	25.53±1.28	21.23±1.06	16.57±0.83	21.11
Mean	25.57	23.10	16.58	
LSD at 5%	L = 0.20	D = 0.16	I = 0.35	
LSD at 1%	L = 0.27	D = 0.21	I = 0.47	
	60 days after germination			
	(1498±47.4 Lux)	(1195±57.7 Lux)	(451±44.2 Lux)	
7	21.33±3.95	18.57±0.81	16.23±1.86	18.71
14	27.77±1.86	21.03±1.53	12.23±2.66	20.34
21	26.67±1.82	15.90±2.31	17.77±2.50	20.11
28	24.57±1.63	18.23±2.25	17.23±1.86	20.01
35	25.57±3.83	20.43±3.20	14.43±1.50	20.14
Mean	25.18	18.83	15.58	
LSD at 5%	L = 2.21	D = NS	I = 3.84	
LSD at 1%	L = 2.98	D = NS	I = 5.17	

Mean ± S.D.

L = Light intensity; D = Days after treatment; I = Interaction; NS = Non significant

Table 56. Stomatal index of abaxial surface of selected invasive plants treated with varying light regimes at two stages of growth (30 and 60 days from germination) (presented as Figure 55).

Days after treatment	Treatments (Luminance stage) Open (100-90%)	Partially shaded (85-70%)	Shaded (35-25%)	Mean
		Mirabilis jalapa		
		30 days after germination		
	(1550±21.8 Lux)	(1249±56.16 Lux)	(451±51.4 Lux)	
7	26.68±1.33	23.33±1.17	22.06±1.10	24.02
14	27.73±1.39	24.68±1.23	20.63±1.03	24.35
21	26.74±1.34	22.19±1.11	20.19±1.01	23.04
28	29.49±1.47	23.67±1.18	22.43±1.12	25.20
35	30.34±1.52	24.12±1.21	20.95±1.05	25.14
Mean	28.20	23.60	21.25	
LSD at 5%	L = 0.15	D = 0.12	I = 0.27	
LSD at 1%	L = 0.21	D = 0.16	I = 0.36	
		60 days after germination		
	(1518±45.5 Lux)	(1236±65.8 Lux)	(466±42.5 Lux)	
7	27.27±1.36	27.60±1.38	21.72±1.09	25.53
14	28.95±1.45	25.46±1.27	22.66±1.13	25.69
21	26.93±1.35	26.09±1.30	20.42±1.02	24.48
28	27.34±1.37	25.86±1.29	22.39±1.12	25.20
35	28.97±1.45	25.41±1.27	21.41±1.07	25.26
Mean	27.89	26.08	21.72	
LSD at 5%	L = 0.14	D = 0.10	I = 0.23	
LSD at 1%	L = 0.18	D = 0.14	I = 0.32	
		Ruellia tuberosa		
		30 days after germination		
	(1503±45.6 Lux)	(1229±61.6 Lux)	(461±35.4 Lux)	
7	36.62±1.83	36.27±1.81	40.46±2.02	37.78
14	37.75±1.89	37.82±1.89	43.11±2.16	39.56
21	37.34±1.87	37.45±1.87	40.75±2.04	38.51
28	36.36±1.82	35.76±1.79	42.22±2.11	38.11
35	36.92±1.85	38.29±1.91	45.06±2.25	40.09
Mean	37.00	37.12	42.32	
LSD at 5%	L = 0.14	D = 0.11	I = 0.24	
LSD at 1%	L = 0.18	D = 0.18	I = 0.32	
		60 days after germination		
	(1498±47.4 Lux)	(1195±57.7 Lux)	(451±44.2 Lux)	
7	30.08±1.50	32.80±1.64	36.82±1.84	33.23
14	33.42±1.67	31.68±1.58	39.77±1.99	34.96
21	30.34±1.52	32.39±1.62	36.06±1.80	32.93
28	31.19±1.56	32.22±1.61	37.29±1.86	33.57
35	34.46±1.72	34.46±1.72	39.70±1.99	36.21
Mean	31.90	32.71	37.93	
LSD at 5%	L = 0.15	D = 0.12	I = 0.26	
LSD at 1%	L = 0.20	D = 0.16	I = 0.35	

Mean ± S.D.

L = Light intensity; D = Days after treatment; I = Interaction; NS = Non significant

Table 57. Proportion of leaf tissues of selected invasive plants with varying light regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 56).

Leaf tissues	Treatments (Luminance stage)			LSD at 5%	LSD at 1%
	Open	Partial shade	Shade		
	Mirabilis jalapa 30 days after germination				
Dermal system	1074.8±96.7	1017.3±91.6	1283.9±115.6	28.62	47 47
Palisade parenchyma	1826.6±164.4	1871.1±168.4	1517.1±136.5	39.34	65 25
Spongy parenchyma	2136.5±192.3	2162.9±194.7	2271.8±204.5	14.63	24 27
Vascular area	102.5±9.2	102.1±9.2	84.2±7.6	2.13	3 54
Total leaf tissue area	5140.4±459.7	5153.4±457.9	5157.0±434.4	31.89	52 90
	60 days after germination				
Dermal system	1107.9±99.7	1003.4±90.3	991.4±89.2	13.07	21 68
Palisade parenchyma	1803.5±162.3	1843.1±165.9	1588.2±143.0	27.99	46 41
Spongy parenchyma	2019.7±181.8	2106.6±189.6	2312.4±208.1	30.66	50 86
Vascular area	101.3±9.1	101.9±9.2	88.4±8.0	1.56	2 58
Total leaf tissue area	5032.4±452.9	5055.0±455.0	4980.4±447.8	8.35	13 84
	Ruellia tuberosa 30 days after germination				
Dermal system	1097.3±98.8	1078.6±97.1	1140.8±102.7	6.51	10 80
Palisade parenchyma	1874.7±168.7	1789.6±161.1	1337.8±120.4	58.88	97 65
Spongy parenchyma	1981.7±178.4	1997.0±179.7	1661.4±149.5	38.67	64 13
Vascular area	50.3±4.5	51.4±4.6	41.0±3.7	1.16	1 93
Total leaf tissue area	5004.0±444.4	4916.6±439.5	4181.0±376.3	86.12	142 84
	60 days after germination				
Dermal system	1101.4±99.1	1023.6±92.1	1097.4±98.8	8.94	14 82
Palisade parenchyma	1833.5±165.0	1804.8±162.5	1395.3±125.6	50.01	82 95
Spongy parenchyma	1903.9±171.4	1992.4±179.3	1689.4±152.1	31.78	52 70
Vascular area	51.1±4.6	49.7±4.5	42.0±3.8	1 00	1 66
Total leaf tissue area	4889.9±437.1	4870.5±438.4	4224.1±380.2	75.33	124 93

Mean ± S.D. (values show area of each tisuue system in µm2 in a vertical section of leaf)
L = Light intensity; D = Days after treatment; I = Interaction; NS = Non significant

Table 58. Floral buds plant^{-1} of selected invasive plants treated with varying light regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 57).

Days after treatment	Treatments (Luminance stage)			Mean
	Open (100-90%)	**Partially shaded (85-70%)**	**Shaded (35-25%)**	
		Mirabilis jalapa		
		30 days after germination		
	(1550±21.8 Lux)	**(1249±56.16 Lux)**	**(451±51.4 Lux)**	
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00
14	5.67±1.53	5.33±1.53	0.00±0.00	3.67
21	10.33±3.06	7.33±2.52	0.00±0.00	5.89
28	11.67±3.21	6.67±1.15	0.00±0.00	6.11
35	12.67±4.93	7.67±4.04	0.00±0.00	6.78
Mean	8.07	5.40	0.00	
LSD at 5%	L = 2.04	D = 1.58	I = 3.53	
LSD at 1%	L = 2.74	D = 2.13	I = 4.75	
		60 days after germination		
	(1518±45.5 Lux)	**(1236±65.8 Lux)**	**(466±42.5 Lux)**	
7	13.33±2.31	16.33±4.93	15.33±3.79	15.00
14	14.67±3.51	16.67±2.08	7.67±1.53	13.00
21	16.67±2.52	17.33±4.04	0.33±0.58	11.44
28	17.33±4.04	18.67±3.06	0.00±0.00	12.00
35	18.67±2.31	18.33±3.06	0.00±0.00	12.33
Mean	16.13	17.47	4.67	
LSD at 5%	L = 2.54	D = NS	I = 4.40	
LSD at 1%	L = 3.42	D = NS	I = 5.92	
		Ruellia tuberosa		
		30 days after germination		
	(1503±45.6 Lux)	**(1229±61.6 Lux)**	**(461±35.4 Lux)**	
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00
14	0.00±0.00	0.00±0.00	0.00±0.00	0.00
21	0.67±0.58	1.67±1.15	0.00±0.00	0.78
28	2.33±0.58	2.33±1.53	0.00±0.00	1.56
35	3.67±0.58	3.67±1.15	0.00±0.00	2.44
Mean	1.33	1.53	0.00	
LSD at 5%	L = 0.58	D = 0.45	I = 1.00	
LSD at 1%	L = 0.78	D = 0.60	I = 1.34	
		60 days after germination		
	(1498±47.4 Lux)	**(1195±57.7 Lux)**	**(451±44.2 Lux)**	
7	5.33±1.53	4.33±1.53	3.67±0.58	4.44
14	4.67±1.15	4.67±1.53	2.33±2.52	3.89
21	5.33±1.15	5.67±1.15	0.67±1.15	3.89
28	5.67±1.53	6.33±2.52	0.00±0.00	4.00
35	6.67±1.15	6.67±1.53	0.00±0.00	4.44
Mean	5.53	5.53	1.33	
LSD at 5%	L = 1.35	D = NS	I = 2.34	
LSD at 1%	L = 1.82	D = NS	I = 3.15	

Mean ± S.D.

L = Light intensity; D = Days after treatment; I = Interaction; NS = Non significant

Table 59. Flower plant^{-1} of selected invasive plants treated with varying light regimes at two stages of growth (30 and 60 days from germination) (presented as Figure 58).

Days after treatment	Treatments (Luminance stage) Open (100-90%)	Partially shaded (85-70%)	Shaded (35-25%)	Mean
	Mirabilis jalapa			
	30 days after germination			
	(1550±21.8 Lux)	**(1249±56.16 Lux)**	**(451±51.4 Lux)**	
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00
14	1.33±1.15	0.33±0.58	0.00±0.00	0.56
21	2.33±1.53	4.33±2.52	0.00±0.00	2.22
28	4.67±2.08	5.67±1.53	0.00±0.00	3.44
35	8.33±3.06	6.33±2.52	0.00±0.00	4.89
Mean	3.33	3.33	0.00	
LSD at 5%	L = 1.38	D = 1.07	I = 2.38	
LSD at 1%	L = 1.85	D = 1.44	I = 3.21	
	60 days after germination			
	(1518±45.5 Lux)	**(1236±65.8 Lux)**	**(466±42.5 Lux)**	
7	7.33±2.52	8.67±1.53	6.67±1.53	7.56
14	9.33±4.51	9.33±2.31	0.67±0.58	6.44
21	11.33±3.21	11.67±1.15	0.00±0.00	7.67
28	10.67±3.21	10.67±3.06	0.00±0.00	7.11
35	11.33±2.52	11.67±4.16	0.00±0.00	7.67
Mean	10.00	10.40	1.47	
LSD at 5%	L = 2.27	D = NS	I = 3.93	
LSD at 1%	L = 3.06	D = NS	I = 5.30	
	Ruellia tuberosa			
	30 days after germination			
	(1503±45.6 Lux)	**(1229±61.6 Lux)**	**(461±35.4 Lux)**	
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00
14	0.00±0.00	0.00±0.00	0.00±0.00	0.00
21	0.00±0.00	0.00±0.00	0.00±0.00	0.00
28	1.67±1.15	1.67±2.08	0.00±0.00	1.11
35	3.33±1.53	2.33±1.15	0.00±0.00	1.89
Mean	1.00	0.80	0.00	
LSD at 5%	L = 0.67	D = 0.52	I = 1.16	
LSD at 1%	L = 0.90	D = 0.70	I = 1.56	
	60 days after germination			
	(1498±47.4 Lux)	**(1195±57.7 Lux)**	**(451±44.2 Lux)**	
7	2.33±0.67	1.67±0.48	0.67±0.19	1.56
14	2.00±0.57	1.33±0.38	0.00±0.00	1.11
21	2.33±0.67	1.67±0.48	0.00±0.00	1.33
28	2.67±0.76	2.33±0.67	0.00±0.00	1.66
35	2.67±0.76	1.67±0.48	0.00±0.00	1.44
Mean	2.40	1.73	0.13	
LSD at 5%	L = 0.28	D = 0.22	I = 0.49	
LSD at 1%	L = 0.38	D = 0.29	I = 0.66	

Mean ± S.D.

L = Light intensity; D = Days after treatment; I = Interaction; NS = Non significant

Table 60. Fruits plant^{-1} of selected invasive plants treated with varying light regimes at two stages of growth (30 and 60 days after germination) (presented as Figure 59).

Days after treatment	Treatments (Luminance stage)			Mean
	Open (100-90%)	Partially shaded (85-70%)	Shaded (35-25%)	
		Mirabilis jalapa		
		30 days after germination		
	(1550±21.8 Lux)	(1249±56.16 Lux)	(451±51.4 Lux)	
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00
14	0.00±0.00	0.00±0.00	0.00±0.00	0.00
21	0.00±0.00	0.00±0.00	0.00±0.00	0.00
28	0.33±0.58	0.67±0.58	0.00±0.00	0.33
35	2.33±1.53	0.67±0.58	0.00±0.00	1.00
Mean	0.53	0.27	0.00	
LSD at 5%	L = 0.45	D = 0.35	I = 0.78	
LSD at 1%	L = 0.60	D = 0.47	I = 1.05	
		60 days after germination		
	(1518±45.5 Lux)	(1236±65.8 Lux)	(466±42.5 Lux)	
7	1.33±0.58	1.67±0.58	2.33±0.58	1.78
14	2.33±1.53	2.67±2.08	0.00±0.00	1.67
21	3.33±1.53	3.67±1.53	0.00±0.00	2.33
28	4.67±1.53	3.33±1.53	0.00±0.00	2.67
35	4.67±1.15	3.33±1.15	0.00±0.00	2.67
Mean	3.27	2.93	0.47	
LSD at 5%	L = 0.95	D = NS	I = 1.64	
LSD at 1%	L = 1.28	D = NS	I = 2.21	
		Ruellia tuberosa		
		30 days after germination		
	(1503±45.6 Lux)	(1229±61.6 Lux)	(461±35.4 Lux)	
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00
14	0.00±0.00	0.00±0.00	0.00±0.00	0.00
21	0.00±0.00	0.00±0.00	0.00±0.00	0.00
28	0.00±0.00	0.00±0.00	0.00±0.00	0.00
35	1.33±0.58	0.33±0.58	0.00±0.00	0.56
Mean	0.27	0.07	0.00	
LSD at 5%	L = 0.19	D = 0.15	I = 0.33	
LSD at 1%	L = 0.25	D = 0.20	I = 0.44	
		60 days after germination		
	(1498±47.4 Lux)	(1195±57.7 Lux)	(451±44.2 Lux)	
7	1.67±0.58	1.33±0.58	2.00±1.00	1.67
14	2.00±1.00	1.33±0.58	0.67±1.15	1.33
21	2.33±1.53	2.00±1.00	0.00±0.00	1.44
28	2.67±1.15	1.67±0.58	0.00±0.00	1.44
35	2.67±1.15	1.67±1.15	0.00±0.00	1.44
Mean	2.27	1.60	0.53	
LSD at 5%	L = 0.73	D = NS	I = 1.27	
LSD at 1%	L = 0.99	D = NS	I = 1.71	

Mean ± S.D.

L = Light intensity; D = Days after treatment; I = Interaction; NS = Non significant

Table 61. Seed output plant^{-1} of selected invasive plants treated with varying light regimes at growth stage (60 days from germination) (presented as Figure 60).

Days after treatment	Treatments (Luminance stage) Open (100-90%)	Partially shaded (85-70%)	Shaded (35-25%)	Mean
		Mirabilis jalapa		
	(1518±45.5 Lux)	(1236±65.8 Lux)	(466±42.5 Lux)	
7	0.00±0.00	0.00±0.00	0.67±1.15	0.22
14	0.00±0.00	0.00±0.00	0.33±0.58	0.11
21	0.00±0.00	0.33±0.58	0.00±0.00	0.11
28	3.67±1.15	1.67±0.58	0.00±0.00	1.78
35	4.33±2.52	3.67±1.53	0.00±0.00	2.67
Mean	1.60	1.13	0.20	
LSD at 5%	L = 0.81	D = 0.63	I = 1.41	
LSD at 1%	L = 1.10	D = 0.85	I = 1.90	
		Ruellia tuberosa		
	(1498±47.4 Lux)	(1195±57.7 Lux)	(451±44.2 Lux)	
7	75.33±3.77	86.33±4.32	41.34±2.07	67.67
14	79.67±3.98	80.67±4.03	25.08±1.25	61.80
21	84.33±4.22	92.33±4.62	18.98±0.95	65.22
28	84.33±4.22	99.67±4.98	0.00±0.00	61.33
35	99.67±4.98	103.67±5.18	0.00±0.00	67.78
Mean	84.67	92.53	17.08	
LSD at 5%	L = 1.78	D = 1.38	I = 3.08	
LSD at 1%	L = 2.40	D = 1.86	I = 4.15	

Mean ± S.D.

L = Light intensity; D = Days after treatment; I = Interaction

Table 62. Plant height (cm) of selected invasive *Mirabilis jalapa* treated with varying root exudates of *Argemone mexicana, Malvastrum coromandelianum* and *Parthenium hysterophorus* at two stages of growth (30 and 60 days after germination) (presented in summary Table 1).

Days after treatment	Treatments										Mean
	Control	*Argemone mexicana*			*Malvastrum coromandelianum*			*Parthenium hysterophorus*			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination										
7	16.72±2.63	14.88±4.36	15.84±1.69	15.36±1.34	16.08±1.57	17.12±1.04	16.80±4.21	17.28±3.13	15.12±2.48	18.72±6.03	16.39
14	17.03±3.34	19.37±2.71	17.59±2.15	19.79±1.32	18.17±1.78	20.24±3.75	19.07±2.21	21.49±2.11	18.34±3.70	18.89±1.40	19.00
21	22.29±5.27	24.59±2.78	23.74±3.26	23.26±5.60	21.42±4.54	23.19±2.01	25.43±1.68	26.38±3.41	24.23±3.54	20.38±2.39	23.49
28	28.36±3.84	29.73±0.71	27.21±3.50	28.09±1.70	26.83±2.48	29.38±3.87	28.78±2.25	30.49±5.68	30.08±3.89	25.38±3.19	28.43
35	31.69±4.58	32.08±2.11	29.48±4.16	28.36±1.88	30.46±2.80	30.78±4.31	32.09±3.58	31.48±1.31	33.45±3.58	30.38±3.86	31.03
Mean	23.22	24.13	22.77	22.97	22.59	24.14	24.43	25.42	24.24	22.75	
LSD at 5%	T = NS	D = 2.33	I = NS								
LSD at 1%	T = NS	D = 3.08	I = NS								
	60 days after germination										
7	33.37±1.82	30.46±2.98	32.39±3.96	31.56±2.86	35.38±3.77	33.50±6.28	30.74±2.08	33.68±2.11	31.59±1.99	32.79±2.22	32.55
14	35.17±2.86	30.63±2.50	34.17±1.67	32.72±2.32	37.03±2.77	36.41±2.24	33.17±2.34	34.04±2.47	32.19±1.97	33.08±1.78	33.86
21	35.89±2.39	32.41±1.48	35.01±2.02	35.66±3.42	37.89±3.05	37.24±3.50	34.08±3.35	34.89±3.20	36.48±3.65	34.16±1.62	35.37
28	37.12±2.91	35.59±2.49	35.43±2.09	36.08±3.17	38.17±2.62	38.24±1.54	37.54±3.45	35.08±2.34	37.38±2.77	35.88±3.27	36.65
35	38.95±3.11	37.99±0.95	38.38±2.39	36.49±2.62	38.42±2.67	38.42±3.18	40.09±2.11	38.46±2.47	39.84±2.34	37.38±1.80	38.44
Mean	36.10	33.42	35.08	34.50	37.38	36.76	35.12	35.23	35.50	34.66	
LSD at 5%	T = 1.37	D = 1.94	I = NS								
LSD at 1%	T = 1.82	D = 2.57	I = NS								

Mean ± S.D.

T = Treatments; D = Days after treatment; I = Interaction; NS = Non significant

Table 63. Leaf plant^{-1} of selected invasive *Mirabilis jalapa* treated with varying root exudates of *Argemone mexicana*, *Malvastrum coromandelianum* and *Parthenium hysterophorus* at two stages of growth (30 and 60 days after germination) (presented in summary Table 1).

Days after treatment	Treatments										Mean
	Control	***Argemone mexicana***			***Malvastrum coromandelianum***			***Parthenium hysterophorus***			
		100ml	**200ml**	**400ml**	**100ml**	**200ml**	**400ml**	**100ml**	**200ml**	**400ml**	
	30 days after germination										
7	20.67±5.69	16.33±3.21	18.67±4.04	23.67±5.03	16.67±4.93	20.33±2.52	22.67±2.08	21.33±3.21	25.67±6.81	20.67±2.08	20.67
14	24.67±3.51	23.67±3.51	21.67±1.53	24.33±2.08	22.33±5.86	20.67±3.51	27.33±1.53	23.67±2.31	26.33±1.53	21.33±3.21	23.80
21	22.33±7.77	24.33±4.04	22.33±3.79	25.33±1.53	26.33±4.93	22.33±1.53	29.33±2.08	26.33±2.89	27.33±5.03	23.67±5.69	25.10
28	28.67±4.04	32.67±2.52	26.33±4.04	28.67±2.52	27.67±3.21	22.67±3.21	33.67±1.53	27.33±3.06	29.67±3.51	25.33±3.79	28.67
35	31.33±3.21	34.67±2.52	30.33±2.31	30.33±4.73	32.33±3.06	26.33±1.15	37.33±2.08	29.33±2.89	33.67±2.08	29.33±1.15	30.77
Mean	25.53	26.33	23.87	26.47	25.07	22.47	30.07	25.60	28.53	24.07	
LSD at 5%	T = 1.70	D = 2.40	I = NS								
LSD at 1%	T = 2.24	D = 3.17	I = NS								
	60 days after germination										
7	34.33±4.04	30.33±3.21	32.67±2.08	30.67±4.51	31.33±6.11	28.67±2.31	34.67±2.52	30.33±4.16	27.33±2.08	35.33±3.21	31.57
14	35.67±10.21	33.67±5.51	33.33±3.06	34.33±2.31	33.67±2.52	29.33±6.81	36.33±3.06	33.33±9.45	34.67±4.51	35.33±3.79	33.97
21	36.33±5.51	36.33±2.31	34.67±2.31	37.67±3.21	34.33±2.08	34.33±3.21	36.67±5.69	34.67±8.33	35.33±4.62	36.67±3.06	35.70
28	37.33±6.03	40.33±2.89	35.33±2.52	38.33±3.21	36.33±5.13	34.67±3.06	38.67±6.66	38.33±9.45	41.67±3.51	37.67±1.53	37.87
35	40.67±3.21	42.33±3.79	36.33±3.79	38.67±4.04	38.67±1.53	36.33±7.09	40.33±2.52	41.67±4.16	43.33±3.21	39.33±2.31	39.77
Mean	36.87	36.60	34.47	35.93	34.87	32.67	37.33	35.67	36.47	36.87	
LSD at 5%	T = NS	D = 3.11	I = NS								
LSD at 1%	T = NS	D = 4.11	I = NS								

Mean ± S.D.

T = Treatments; D = Days after treatment; I = Interaction; NS = Non significant

Table 64. Leaf area expansion (cm^2) of selected invasive *Mirabilis jalapa* treated with varying root exudates of *Argemone mexicana*, *Malvastrum coromandelianum* and *Parthenium hysterophorus* at two stages of growth (30 and 60 days from germination) (presented in summary Table 1).

Days after treatment	Treatments										Mean
	Control	*Argemone mexicana*			*Malvastrum coromandelianum*			*Parthenium hysterophorus*			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination										
7	5.34±1.89	4.68±1.65	7.21±2.55	6.48±2.29	5.39±1.90	4.38±1.55	4.74±1.67	7.26±2.57	6.41±2.27	7.07±2.50	5.90
14	16.75±5.92	24.27±8.58	23.83±8.42	21.83±7.71	17.50±6.18	19.50±6.89	20.50±7.24	18.83±6.65	18.75±6.63	21.50±7.60	20.33
21	25.53±9.02	25.67±9.07	25.50±9.01	23.67±8.36	26.50±9.36	27.50±9.72	23.80±8.41	20.67±7.30	21.83±7.71	25.17±8.89	24.58
28	29.27±10.34	28.50±10.07	28.17±9.95	30.50±10.78	27.83±9.83	31.83±11.25	29.52±10.43	25.17±8.89	22.67±8.01	23.33±8.24	27.68
35	30.17±10.66	33.83±11.95	29.38±10.38	30.67±10.84	30.38±10.73	32.76±11.58	35.36±12.49	28.37±10.02	32.33±11.42	29.83±10.54	31.31
Mean	21.41	23.39	22.82	22.63	21.52	23.19	22.78	20.06	20.40	21.38	
LSD at 5%	T = NS	D = 2.34	I = NS								
LSD at 1%	T = NS	D = 3.09	I = NS								
	60 days after germination										
7	8.45±1.81	7.45±1.96	9.36±1.63	5.31±2.30	8.11±3.02	4.38±1.89	3.42±0.55	8.39±1.77	9.38±4.18	6.45±1.95	7.07
14	18.64±4.28	21.50±1.35	19.19±5.96	20.13±2.58	21.50±2.59	22.50±1.86	23.50±2.76	14.36±1.13	17.39±6.16	18.73±1.40	19.74
21	26.27±7.23	24.67±3.48	24.17±3.98	26.33±3.27	25.83±3.51	24.36±6.04	27.19±3.96	25.27±5.04	23.38±3.98	20.17±2.31	24.76
28	31.75±5.63	36.17±1.65	34.93±1.90	35.38±0.68	31.71±4.04	33.56±4.17	35.93±3.01	36.76±3.86	38.41±1.55	35.60±1.95	35.02
35	39.67±3.90	42.29±2.05	38.36±1.55	39.13±4.72	36.78±4.56	38.42±5.23	40.53±5.05	41.38±5.86	44.76±2.19	38.29±2.39	39.96
Mean	24.96	26.42	25.20	25.26	24.79	24.64	26.11	25.23	26.66	23.85	
LSD at 5%	T = NS	D = 2.48	I = NS								
LSD at 1%	T = NS	D = 3.28	I = NS								

Mean ± S.D.

T = Treatments; D = Days after treatment; I = Interaction; NS = Non significant

Table 65. Relative water content (%) of selected invasive *Mirabilis jalapa* treated with varying root exudates of *Argemone mexicana*, *Malvastrum coromandelianum* and *Parthenium hysterophorus* at two stages of growth (30 and 60 days after germination) (presented in summary Table 1).

Days after treatment	Treatments										Mean
	Control	*Argemone mexicana*			*Malvastrum coromandelianum*			*Parthenium hysterophorus*			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination										
7	88.94±1.97	90.12±3.85	89.36±2.42	88.31±3.36	88.89±2.01	89.98±1.08	89.36±2.36	88.08±2.57	88.36±2.60	88.92±1.42	89.03
14	88.39±1.50	89.71±0.74	88.86±4.15	88.98±5.08	87.88±6.86	87.68±4.02	88.67±0.85	88.21±2.88	88.73±0.90	88.38±1.63	88.55
21	86.98±2.25	88.42±4.00	88.36±2.97	88.42±2.30	87.56±0.92	88.38±3.04	88.88±1.57	86.78±2.53	87.62±1.85	87.68±2.51	87.91
28	87.34±0.40	87.36±2.56	86.98±0.66	87.98±3.68	88.98±1.50	86.88±4.03	88.36±1.82	87.56±2.59	86.89±3.63	87.88±1.82	87.62
35	87.96±1.68	86.98±3.44	87.34±2.94	87.26±1.90	87.68±2.47	86.38±2.64	87.08±0.62	86.98±2.69	87.34±4.37	87.52±2.74	87.25
Mean	87.92	88.52	88.18	88.19	88.20	87.86	88.47	87.52	87.79	88.08	
LSD at 5%	T = NS	D = NS	I = NS								
LSD at 1%	T = NS	D = NS	I = NS								
	60 days after germination										
7	88.24±1.08	87.03±2.09	87.56±5.19	87.86±1.03	87.03±2.94	86.98±0.70	87.68±3.91	87.13±2.63	87.98±2.85	87.98±3.12	87.55
14	87.95±1.74	86.98±0.86	87.69±1.34	86.31±1.67	86.42±3.06	87.68±2.68	86.87±1.90	87.08±1.08	88.03±0.57	88.14±3.33	87.32
21	86.81±2.09	85.87±3.42	86.38±3.70	86.54±1.56	85.56±0.84	86.31±1.09	87.36±1.25	87.41±3.19	86.89±2.87	87.17±2.44	86.63
28	85.74±4.16	85.38±1.75	85.53±3.92	85.74±3.67	85.17±4.68	86.78±2.21	87.49±2.45	85.62±2.44	86.21±3.90	85.08±2.50	85.87
35	85.09±2.40	84.98±2.43	85.36±2.92	85.88±2.68	85.58±2.32	84.78±2.92	85.73±3.72	85.39±4.48	85.98±3.24	85.17±2.23	85.39
Mean	86.77	86.05	86.50	86.47	85.95	86.51	87.03	86.53	87.02	86.71	
LSD at 5%	T = NS	D = 1.98	I = NS								
LSD at 1%	T = NS	D = 2.62	I = NS								

Mean ± S.D.

T = Treatments; D = Days after treatment; I = Interaction; NS = Non significant

Table 66. Chlorophyll a (mg g^{-1} fresh weight) of selected invasive *Mirabilis jalapa* treated with varying root exudates of *Argemone mexicana*, *Malvastrum coromandelianum* and *Parthenium hysterophorus* at two stages of growth (30 and 60 days after germination) (presented in summary Table 1).

Days after treatment	Treatments										Mean
	Control	*Argemone mexicana*			*Malvastrum coromandelianum*			*Parthenium hysterophorus*			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination										
7	0.859±0.025	0.843±0.020	0.858±0.027	0.861±0.035	0.854±0.009	0.849±0.017	0.863±0.010	0.855±0.013	0.857±0.028	0.862±0.018	0.856
14	0.884±0.022	0.868±0.008	0.882±0.007	0.869±0.014	0.874±0.030	0.886±0.009	0.883±0.011	0.879±0.014	0.883±0.007	0.874±0.008	0.878
21	0.867±0.041	0.853±0.030	0.874±0.022	0.885±0.006	0.864±0.041	0.872±0.033	0.862±0.029	0.875±0.014	0.879±0.009	0.877±0.007	0.871
28	0.873±0.012	0.882±0.023	0.891±0.013	0.886±0.011	0.878±0.015	0.872±0.015	0.885±0.010	0.874±0.011	0.873±0.005	0.869±0.013	0.878
35	0.896±0.017	0.889±0.014	0.894±0.009	0.898±0.013	0.875±0.023	0.880±0.008	0.891±0.013	0.886±0.008	0.874±0.004	0.877±0.018	0.886
Mean	0.876	0.867	0.880	0.880	0.869	0.872	0.877	0.874	0.873	0.872	
LSD at 5%	T = NS	D = 0.014	I = NS								
LSD at 1%	T = NS	D = 0.018	I = NS								
	60 days after germination										
7	0.873±0.072	0.880±0.017	0.876±0.012	0.884±0.017	0.872±0.023	0.868±0.023	0.875±0.018	0.876±0.024	0.884±0.007	0.879±0.014	0.877
14	0.896±0.019	0.878±0.009	0.884±0.007	0.864±0.010	0.893±0.017	0.877±0.008	0.882±0.010	0.886±0.015	0.879±0.018	0.872±0.016	0.881
21	0.883±0.029	0.882±0.017	0.892±0.016	0.876±0.019	0.895±0.020	0.896±0.013	0.888±0.016	0.905±0.024	0.886±0.024	0.889±0.015	0.889
28	0.901±0.010	0.886±0.010	0.894±0.014	0.892±0.019	0.887±0.014	0.904±0.022	0.902±0.020	0.892±0.023	0.882±0.007	0.883±0.016	0.892
35	0.906±0.008	0.898±0.022	0.912±0.010	0.886±0.011	0.894±0.008	0.890±0.016	0.885±0.010	0.882±0.016	0.879±0.018	0.876±0.009	0.891
Mean	0.892	0.885	0.892	0.880	0.888	0.887	0.886	0.888	0.882	0.880	
LSD at 5%	T = NS	D = 0.014	I = NS								
LSD at 1%	T = NS	D = 0.018	I = NS								

Mean ± S.D.

T = Treatments; D = Days after treatment; I = Interaction; NS = Non significant

Table 67. Chlorophyll b (mg g^{-1} fresh weight) of selected invasive *Mirabilis jalapa* treated with varying root exudates of *Argemone mexicana*, *Malvastrum coromandelianum* and *Parthenium hysterophorus* at two stages of growth (30 and 60 days after germination) (presented in summary Table 1).

Days after treatment	Treatments										Mean
	Control	*Argemone mexicana*			*Malvastrum coromandelianum*			*Parthenium hysterophorus*			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination										
7	0.332±0.026	0.326±0.021	0.330±0.012	0.328±0.025	0.321±0.027	0.325±0.013	0.319±0.016	0.335±0.006	0.331±0.006	0.329±0.007	0.328
14	0.352±0.021	0.342±0.029	0.332±0.016	0.364±0.026	0.359±0.013	0.356±0.017	0.358±0.016	0.349±0.015	0.342±0.010	0.359±0.009	0.351
21	0.374±0.010	0.356±0.021	0.361±0.010	0.372±0.019	0.359±0.014	0.376±0.016	0.379±0.010	0.369±0.012	0.369±0.021	0.372±0.015	0.369
28	0.394±0.039	0.374±0.015	0.359±0.006	0.389±0.013	0.381±0.014	0.382±0.010	0.392±0.022	0.388±0.005	0.380±0.004	0.368±0.017	0.381
35	0.388±0.032	0.382±0.011	0.379±0.018	0.392±0.012	0.386±0.026	0.380±0.010	0.388±0.018	0.378±0.013	0.387±0.007	0.383±0.005	0.384
Mean	0.368	0.356	0.352	0.369	0.361	0.364	0.367	0.364	0.362	0.362	
LSD at 5%	T = NS	D = 0.012	I = NS								
LSD at 1%	T = NS	D = 0.016	I = NS								
	60 days after germination										
7	0.394±0.013	0.386±0.008	0.398±0.017	0.382±0.011	0.380±0.011	0.375±0.020	0.382±0.015	0.401±0.018	0.397±0.016	0.389±0.018	0.388
14	0.385±0.020	0.392±0.007	0.388±0.018	0.388±0.016	0.383±0.010	0.384±0.009	0.383±0.003	0.398±0.020	0.396±0.007	0.385±0.011	0.388
21	0.396±0.030	0.398±0.012	0.392±0.015	0.392±0.008	0.376±0.026	0.388±0.022	0.389±0.006	0.392±0.018	0.399±0.015	0.394±0.014	0.392
28	0.391±0.033	0.394±0.010	0.395±0.014	0.390±0.015	0.382±0.012	0.396±0.026	0.386±0.016	0.411±0.016	0.406±0.013	0.397±0.012	0.395
35	0.407±0.018	0.401±0.017	0.398±0.004	0.405±0.020	0.388±0.009	0.392±0.025	0.389±0.017	0.412±0.008	0.406±0.003	0.399±0.018	0.400
Mean	0.395	0.394	0.394	0.391	0.382	0.387	0.386	0.403	0.401	0.393	
LSD at 5%	T = 0.008	D = 0.012	I = NS								
LSD at 1%	T = 0.011	D = 0.015	I = NS								

Mean ± S.D.

T = Treatments; D = Days after treatment; I = Interaction; NS = Non significant

Table 68. Total chlorophyll (mg g^{-1} fresh weight) of selected invasive *Mirabilis jalapa* treated with varying root exudates of *Argemone mexicana*, *Malvastrum coromandelianum* and *Parthenium hysterophorus* at two stages of growth (30 and 60 days after germination) (presented in summary Table 1).

Days after treatment	Treatments										Mean
	Control	*Argemone mexicana*			*Malvastrum coromandelianum*			*Parthenium hysterophorus*			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination										
7	1.191±0.047	1.169±0.014	1.188±0.016	1.189±0.058	1.175±0.022	1.174±0.014	1.182±0.012	1.190±0.019	1.188±0.024	1.191±0.024	1.184
14	1.236±0.002	1.210±0.029	1.224±0.018	1.233±0.016	1.233±0.018	1.242±0.021	1.241±0.010	1.228±0.008	1.225±0.015	1.242±0.007	1.231
21	1.241±0.044	1.209±0.031	1.235±0.021	1.257±0.018	1.223±0.029	1.248±0.018	1.241±0.023	1.244±0.019	1.249±0.022	1.249±0.010	1.240
28	1.267±0.051	1.256±0.038	1.249±0.015	1.275±0.014	1.259±0.023	1.254±0.012	1.277±0.031	1.262±0.012	1.253±0.001	1.236±0.012	1.259
35	1.284±0.049	1.271±0.014	1.273±0.023	1.290±0.017	1.261±0.007	1.260±0.018	1.279±0.030	1.264±0.021	1.261±0.005	1.260±0.023	1.270
Mean	1.244	1.223	1.234	1.249	1.230	1.236	1.244	1.238	1.235	1.236	
LSD at 5%	T = NS	D = 0.017	I = NS								
LSD at 1%	T = NS	D = 0.023	I = NS								
	60 days after germination										
7	1.267±0.082	1.266±0.021	1.274±0.020	1.266±0.026	1.252±0.023	1.243±0.043	1.257±0.004	1.277±0.007	1.281±0.016	1.268±0.032	1.265
14	1.281±0.030	1.270±0.006	1.272±0.014	1.252±0.007	1.276±0.025	1.261±0.004	1.265±0.007	1.284±0.035	1.275±0.025	1.257±0.010	1.269
21	1.279±0.014	1.280±0.014	1.284±0.030	1.268±0.015	1.271±0.045	1.284±0.035	1.277±0.015	1.297±0.009	1.282±0.031	1.283±0.029	1.280
28	1.292±0.041	1.280±0.003	1.289±0.016	1.282±0.034	1.269±0.024	1.300±0.005	1.288±0.007	1.303±0.039	1.288±0.017	1.280±0.004	1.287
35	1.313±0.026	1.299±0.038	1.310±0.013	1.291±0.018	1.282±0.016	1.283±0.011	1.274±0.025	1.294±0.022	1.285±0.017	1.275±0.033	1.291
Mean	1.286	1.279	1.286	1.272	1.270	1.274	1.272	1.291	1.282	1.273	
LSD at 5%	T = NS	D = 0.019	I = NS								
LSD at 1%	T = NS	D = 0.025	I = NS								

Mean ± S.D.

T = Treatments; D = Days after treatment; I = Interaction; NS = Non significant

Table 69. Above ground biomass (g) of selected invasive *Mirabilis jalapa* treated with varying root exudates of *Argemone mexicana*, *Malvastrum coromandelianum* and *Parthenium hysterophorus* at two stages of growth (30 and 60 days after germination) (presented in summary Table 1).

Days after Germination	Treatments										LSD at	
	Control	*Argemone mexicana*			*Malvastrum coromandelianum*			*Parthenium hysterophorus*				
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	5%	1%
30	1.90±0.22	2.10±0.79	1.80±0.87	1.70±0.42	1.70±0.52	1.85±0.53	1.91±0.48	2.20±0.13	2.08±0.15	2.10±0.32	NS	NS
60	3.20±0.36	3.05±0.37	3.30±0.72	2.90±0.43	2.40±0.68	3.09±0.21	3.25±0.63	3.35±0.17	3.10±0.40	2.90±0.26	NS	NS

Mean ± S.D.
NS = Non-significant

Table 70. Stomata number of abaxial surface of selected invasive *Mirabilis jalapa* treated with varying root exudates of *Argemone mexicana*, *Malvastrum coromandelianum* and *Parthenium hysterophorus* at two stages of growth (30 and 60 days after germination) (presented in summary Table 1).

Days after treatment	Treatments										Mean
	Control	*Argemone mexicana*			*Malvastrum coromandelianum*			*Parthenium hysterophorus*			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination										
7	10.33±4.68	12.77±4.84	13.00±0.31	10.37±1.53	8.77±1.86	10.10±3.36	7.90±2.78	9.90±2.99	8.43±2.73	11.43±1.63	10.30
14	10.67±2.22	12.23±1.50	10.43±2.58	11.40±2.26	7.97±2.08	10.77±3.14	11.77±2.25	10.57±0.81	10.57±1.96	11.90±1.06	10.83
21	11.33±5.35	13.47±2.40	14.10±2.99	11.43±1.80	10.80±1.82	12.13±2.21	15.43±2.50	11.77±2.54	8.90±2.03	10.67±1.42	12.00
28	11.33±1.74	10.43±2.80	11.10±3.30	10.67±3.15	13.10±2.55	11.23±2.25	12.57±4.13	10.77±2.34	11.33±2.63	8.23±1.75	11.08
35	10.23±3.93	11.77±1.57	9.77±3.14	13.90±2.15	12.00±3.73	13.77±2.16	10.57±3.01	12.33±4.10	10.57±1.63	10.77±3.14	11.57
Mean	10.78	12.13	11.68	11.55	10.53	11.60	11.65	11.07	9.96	10.60	
LSD at 5%	T = NS	D = NS	I = NS								
LSD at 1%	T = NS	D = NS	I = NS								
	60 days after germination										
7	11.00±2.17	13.90±1.39	12.43±2.73	17.90±4.95	9.10±3.54	9.43±1.03	12.23±1.75	12.77±1.29	9.10±2.31	11.33±2.57	11.92
14	11.77±3.88	16.53±2.93	15.77±0.50	16.03±3.79	11.90±1.93	12.37±3.79	17.43±2.01	9.67±3.51	11.23±1.29	11.67±1.65	13.44
21	12.67±5.61	15.70±1.73	11.87±1.40	12.47±4.53	10.70±1.73	14.23±2.34	11.43±1.96	13.90±2.71	11.33±2.22	12.77±4.84	12.71
28	14.37±1.53	13.67±5.27	15.43±0.98	14.57±2.58	13.67±3.15	10.77±1.75	14.90±2.55	11.80±1.91	12.00±1.30	13.57±1.86	13.47
35	14.67±3.21	13.43±0.81	14.57±1.80	13.57±1.40	16.33±3.26	11.67±4.23	13.67±2.41	15.53±3.66	10.87±2.14	14.00±3.21	13.83
Mean	12.89	14.65	14.01	14.91	12.34	11.69	13.93	12.73	10.91	12.67	
LSD at 5%	T = 1.39	D = NS	I = NS								
LSD at 1%	T = 1.84	D = NS	I = NS								

Mean ± S.D.

T = Treatments; D = Days after treatment; I = Interaction; NS = Non significant

Stomata number = per cm^2 area

Table 71. Stomatal index of abaxial surface of selected invasive *Mirabilis jalapa* treated with varying root exudates of *Argemone mexicana*, *Malvastrum coromandelianum* and *Parthenium hysterophorus* at two stages of growth (30 and 60 days after germination) (presented in summary Table 1).

Days after treatment	Treatments										Mean
	Control	*Argemone mexicana*			*Malvastrum coromandelianum*			*Parthenium hysterophorus*			
		100ml	**200ml**	**400ml**	**100ml**	**200ml**	**400ml**	**100ml**	**200ml**	**400ml**	
	30 days after germination										
7	24.39±1.98	24.08±4.19	20.59±2.00	25.75±3.85	24.78±4.25	20.79±3.53	25.09±0.71	22.77±3.48	25.59±1.91	20.38±2.29	23.42
14	26.74±3.43	25.84±4.17	28.75±3.97	29.48±4.38	22.79±5.52	24.36±2.83	28.38±2.42	25.46±2.72	28.11±1.62	26.68±3.04	26.66
21	24.35±2.26	22.17±0.87	26.75±4.00	30.12±2.89	26.53±4.06	26.79±2.39	26.34±3.42	27.21±3.48	30.36±1.78	26.35±2.91	26.70
28	28.45±0.98	27.61±3.65	32.82±1.64	31.02±2.11	29.42±1.59	27.59±4.32	31.76±1.46	30.36±2.30	34.02±1.65	29.59±1.87	30.26
35	39.06±0.65	38.68±1.98	36.72±2.87	39.34±1.53	36.33±3.96	39.72±0.68	40.21±0.23	39.72±0.85	34.79±1.32	36.59±1.85	38.12
Mean	28.60	27.68	29.13	31.14	27.97	27.85	30.36	29.10	30.57	27.92	
LSD at 5%	T = 1.46	D = 2.07	I = NS								
LSD at 1%	T = 1.93	D = 2.73	I = NS								
	60 days after germination										
7	26.88±5.54	22.31±2.74	25.36±3.15	24.42±2.94	28.41±1.87	24.52±1.04	28.42±2.16	27.75±1.11	25.42±1.38	22.38±2.67	25.59
14	27.75±1.30	25.49±1.49	26.75±1.32	25.98±2.32	26.79±3.02	27.59±2.14	29.46±1.76	29.38±1.22	26.68±1.97	23.41±1.93	26.93
21	29.08±2.90	24.38±3.84	29.38±1.10	27.71±1.77	26.48±4.23	29.36±1.73	30.01±2.14	28.69±1.61	29.13±0.87	26.78±2.25	28.10
28	26.78±2.01	25.74±1.13	26.59±1.35	25.36±0.90	31.75±1.03	29.08±2.08	30.64±2.55	29.86±0.38	29.02±2.88	28.05±0.90	28.29
35	29.83±1.31	28.41±1.61	28.72±2.09	30.02±2.01	30.68±2.64	28.21±4.53	32.08±2.95	30.79±2.38	29.68±2.85	28.72±1.41	29.71
Mean	28.06	25.27	27.36	26.70	28.82	27.75	30.12	29.29	27.99	25.87	
LSD at 5%	T = 1.17	D = 1.67	I = NS								
LSD at 1%	T = 1.55	D = 2.21	I = NS								

Mean ± S.D.

T = Treatments; D = Days after treatment; I = Interaction; NS = Non significant

Table 72. Proportion of leaf tissues of selected invasive *Mirabilis jalapa* treated with varying root exudates of *Argemone mexicana*, *Malvastrum coromandelianum* and *Parthenium hysterophorus* at two stages of growth (30 and 60 days from germination) (presented in summary Table 1).

Leaf tissues	Control	Treatments									LSD at	
		Argemone mexicana			*Malvastrum coromandelianum*			*Parthenium hysterophorus*				
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	5%	1%
30 days after germination												
Dermal system	1026 6±114 1	1017 1±113 0	1024 5±113 8	1025 6±114 0	1021 4±113 5	1022 3±113 6	1012 1±112 5	1024 1±113 8	1029 4±114 4	1019 3±113 3	NS	NS
Palisade parenchyma	1812 9±201 4	1807 1±200 8	1825 3±202 8	1810 6±201 2	1820 7±202 3	1816 9±201 9	1822 3±202 5	1815 4±201 7	1809 2±201 0	1824 5±202 7	NS	NS
Spongy parenchyma	2171 5±241 3	2182 4±242 5	2167 9±240 9	2180 1±242 2	2161 5±240 2	2170 9±241 2	2163 3±240 4	2153 7±239 3	2181 2±242 4	2169 2±241 0	NS	NS
Vascular area	103 2±11 2	100 6±11 2	102 1±11 3	100 9±11 2	101 5±11 3	101 1±11 2	101 8±11 3	101 3±11 3	100 8±11 2	100 8±11 2	NS	NS
Total leaf tissue area	5114 2±568 0	5107 2±567 5	5119 8±569 6	5117 2±568 6	5105 1±567 2	5111 2±567 9	5099 5±566 6	5094 5±568 3	5120 6±569 0	5113 8±568 2	NS	NS
60 days after germination												
Dermal system	1121 2±120 0	1195 6±246 1	1163 4±202 0	1108 2±119 3	1090 4±133 6	1057 5±47 6	1075 8±83 6	1032 2±98 6	1083 3±95 3	1043 6±236 4	NS	NS
Palisade parenchyma	1966 8±248 0	1926 7±189 4	1875 4±78 6	1893 5±128 7	1851 4±43 6	1835 2±218 8	1908 3±164 7	1956 7±247 4	1937 8±181 3	1982 3±292 7	NS	NS
Spongy parenchyma	2036 4±149 3	2364 4±398 4	2296 8±284 1	2034 6±211 9	2203 4±115 1	2089 3±116 4	2316 4±321 1	2085 3±97 8	2207 2±148 0	2306 5±308 1	NS	NS
Vascular area	111 0±12 6	107 3±8 3	113 6±31 5	121 5±27 8	115 8±28 5	109 4±15 3	98 4±7 1	112 2±13 0	125 1±36 0	113 6±14 6	NS	NS
Total leaf tissue area	5235 4±172 5	5394 0±464 9	5449 2±290 8	5157 8±9 4	5261 0±71 4	5091 4±438 1	5398 4±224 6	5186 4±82 4	5353 4±271 0	5446 0±385 2	NS	NS

Mean ± S.D (values show area of each tissue system in μm^2 in a vertical section of leaf)
NS = Non significant

Table 73. Floral buds plant[-1] of selected invasive *Mirabilis jalapa* treated with varying root exudates of *Argemone mexicana*, *Malvastrum coromandelianum* and *Parthenium hysterophorus* at two stages of growth (30 and 60 days after germination) (presented in summary Table 1).

Days after treatment	Treatments										
	Control	*Argemone mexicana*			*Malvastrum coromandelianum*			*Parthenium hysterophorus*			Mean
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination										
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
14	7.33±2.31	9.33±2.31	8.70±5.13	7.67±2.89	5.67±3.06	6.67±2.08	7.33±1.15	6.67±1.53	6.33±2.52	8.00±3.61	7.37
21	9.67±3.51	11.30±2.52	9.33±2.31	8.33±2.52	9.33±3.06	7.33±1.53	6.67±2.52	6.33±3.51	9.33±6.11	8.33±4.16	8.60
28	12.33±5.13	10.33±1.15	10.33±6.81	8.67±2.52	10.30±1.15	8.33±2.08	9.33±2.08	10.33±2.08	12.67±1.53	10.33±2.52	10.30
35	11.67±2.52	12.67±2.89	9.67±2.08	10.33±4.16	10.67±2.52	10.33±1.15	11.33±1.53	10.67±4.04	13.33±6.03	11.67±4.04	11.23
Mean	8.20	8.73	7.61	7.00	7.19	6.53	6.93	6.80	8.33	7.67	
LSD at 5%	T = NS	D = 2.24	I = NS								
LSD at 1%	T = NS	D = 2.96	I = NS								
	60 days after germination										
7	13.67±1.53	12.67±2.08	10.33±3.21	11.33±2.52	13.67±5.03	14.67±4.73	12.67±6.43	10.33±3.06	11.67±3.51	13.33±2.52	12.43
14	15.67±2.52	15.67±2.52	12.33±4.51	11.70±4.04	15.30±3.61	16.67±4.16	16.33±3.06	14.67±5.03	12.67±3.21	13.67±3.51	14.47
21	17.67±2.52	15.33±3.51	16.67±4.16	14.67±2.31	15.33±4.16	17.33±2.52	17.67±4.04	17.33±3.79	12.33±2.52	16.33±2.31	16.07
28	17.33±1.53	17.33±1.53	19.33±2.08	17.30±3.51	16.30±4.73	18.33±2.31	17.67±2.52	19.67±4.04	15.33±3.79	15.67±2.08	17.43
35	18.67±4.16	18.67±4.73	20.33±1.53	17.33±3.06	19.67±5.51	21.33±1.53	18.33±5.51	19.33±3.51	17.67±2.08	19.33±4.16	19.07
Mean	16.60	15.93	15.80	14.47	16.05	17.67	16.53	16.27	13.93	15.67	
LSD at 5%	T = NS	D = 2.51	I = NS								
LSD at 1%	T = NS	D = 3.32	I = NS								

Mean ± S.D.

T = Treatments, D – Days after treatment; I = Interaction; NS = Non significant

Table 74. Flower plant^{-1} of selected invasive *Mirabilis jalapa* treated with varying root exudates of *Argemone mexicana*, *Malvastrum coromandelianum* and *Parthenium hysterophorus* at two stages of growth (30 and 60 days after germination) (presented in summary Table 1).

Days after treatment	Treatments										
	Control	*Argemone mexicana*			*Malvastrum coromandelianum*			*Parthenium hysterophorus*			Mean
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination										
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
14	0.67±1.15	0.33±0.58	0.33±0.58	0.67±0.58	1.67±1.53	0.00±0.00	0.33±0.58	1.33±0.58	0.67±1.15	0.00±0.00	0.60
21	3.67±1.53	4.00±1.00	2.67±1.53	3.33±0.58	5.67±1.53	2.67±2.08	0.67±0.58	2.33±1.53	5.67±2.08	1.33±0.58	3.20
28	5.67±2.52	6.33±2.52	5.33±1.53	4.33±1.53	6.33±1.15	8.00±2.65	4.33±1.15	2.67±0.58	5.33±1.53	5.67±2.31	5.40
35	7.33±0.58	9.00±1.73	8.00±1.53	6.33±3.06	7.33±3.06	9.33±2.52	8.67±2.31	6.33±2.89	7.33±1.53	7.67±3.51	7.73
Mean	3.47	3.93	3.27	2.93	4.20	4.00	2.80	2.53	3.80	2.93	
LSD at 5%	T = NS	D = 1.24	I = NS								
LSD at 1%	T = NS	D = 1.64	I = NS								
	60 days after germination										
7	6.67±2.89	8.33±2.52	5.33±2.31	5.67±1.53	6.67±2.08	7.67±2.31	9.33±1.15	8.00±2.00	8.33±3.51	6.33±2.52	7.23
14	8.67±3.51	9.67±2.52	6.33±1.53	7.67±1.53	8.33±2.08	6.33±1.53	8.33±3.51	6.67±2.52	9.33±3.21	7.33±3.21	7.87
21	10.67±3.21	10.33±3.51	8.67±1.53	6.33±3.21	8.33±4.16	9.33±1.53	9.67±2.52	7.33±2.08	10.67±3.06	8.67±2.52	9.00
28	11.67±3.79	9.67±2.31	10.67±0.58	8.30±1.15	10.33±1.53	11.33±3.06	11.67±4.73	9.67±2.08	10.33±2.08	8.67±4.73	10.23
35	12.33±2.08	10.67±2.08	12.67±5.69	11.33±2.08	11.67±2.08	10.33±1.53	12.33±4.16	12.67±1.53	11.33±2.31	11.67±4.04	11.70
Mean	10.00	9.73	8.73	7.86	9.07	9.00	10.27	8.87	10.00	8.53	
LSD at 5%	T = NS	D = 1.95	I = NS								
LSD at 1%	T = NS	D = 2.58	I = NS								

Mean ± S.D.

T = Treatments; D = Days after treatment; I = Interaction; NS = Non significant

Table 75. Fruit plant^{-1} of selected invasive *Mirabilis jalapa* treated with varying root exudates of *Argemone mexicana*, *Malvastrum coromandelianum* and *Parthenium hysterophorus* at two stages of growth (30 and 60 days after germination) (presented in summary Table 1).

Days after treatment	Treatments										Mean
	Control	*Argemone mexicana*			*Malvastrum coromandelianum*			*Parthenium hysterophorus*			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination										
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
14	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
21	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
28	0.33±0.58	0.67±1.15	1.33±1.53	0.67±0.58	0.33±0.58	0.33±0.58	0.67±0.58	0.67±1.15	1.33±0.58	1.33±1.15	0.77
35	2.33±1.53	1.67±0.58	2.33±1.53	2.33±1.53	2.33±1.15	3.33±1.53	1.67±1.15	2.00±1.00	1.67±0.58	3.33±1.15	2.30
Mean	0.53	0.47	0.73	0.60	0.53	0.73	0.47	0.53	0.60	0.93	
LSD at 5%	T = NS	D = 0.73	I = NS								
LSD at 1%	T = NS	D = 0.98	I = NS								
	60 days after germination										
7	1.67±1.15	2.33±0.58	1.33±0.58	2.33±1.53	1.67±0.58	1.67±1.15	2.33±1.15	2.67±2.08	1.67±0.58	1.67±1.15	1.93
14	2.00±1.00	2.67±1.53	3.67±1.15	3.33±1.53	3.33±1.53	2.33±0.58	2.33±1.15	2.33±1.53	2.67±2.08	2.33±1.53	2.70
21	2.67±1.53	2.67±1.15	4.67±2.08	2.67±0.58	2.67±1.53	3.67±2.08	2.67±0.58	3.67±1.15	2.33±1.53	3.33±1.53	3.10
28	3.33±2.31	3.33±0.58	4.00±1.00	2.67±1.15	4.00±1.00	4.33±2.31	3.33±1.53	3.67±1.53	3.67±2.08	3.33±1.15	3.57
35	4.33±2.08	3.67±1.53	4.67±1.53	3.33±1.53	4.33±0.58	3.67±1.15	3.67±1.53	4.30±1.00	4.67±1.53	3.67±2.31	4.03
Mean	2.80	2.93	3.67	2.87	3.20	3.13	2.87	3.33	3.00	2.87	
LSD at 5%	T = NS	D = 1.00	I = NS								
LSD at 1%	T = NS	D = 1.32	I = NS								

Mean ± S.D.

T = Treatments; D = Days after treatment; I = Interaction; NS = Non significant

Table 76. Seed output plant^{-1} of selected invasive *Mirabilis jalapa* treated with varying root exudates of *Argemone mexicana*, *Malvastrum coromandelianum* and *Parthenium hysterophorus* at two stages of growth (30 and 60 days after germination) (presented in summary Table 1).

Days after treatment	Treatments										Mean
	Control	*Argemone mexicana*			*Malvastrum coromandelianum*			*Parthenium hysterophorus*			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination										
7	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
14	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
21	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00
28	2.33±1.53	1.67±1.53	2.67±1.15	1.67±0.58	1.33±1.53	2.33±0.58	2.33±1.53	2.67±1.53	3.33±1.53	1.67±1.15	2.20
35	4.67±1.53	5.33±2.08	4.33±1.53	4.33±0.58	4.67±1.53	4.67±1.15	3.67±1.15	4.33±1.15	4.00±2.65	4.67±2.31	4.47
Mean	1.40	1.40	1.40	1.20	1.20	1.40	1.20	1.40	1.47	1.27	
LSD at 5%	T = NS	D = 0.98	I = NS								
LSD *at 1%*	*T = NS*	*D = 1.32*	*I = NS*								

Mean ± S.D.

T = Treatments; D = Days after treatment; I = Interaction; NS = Non significant

Table 77. Plant height (cm) of selected invasive *Ruellia tuberosa* treated with varying root exudates of *Achyranthes aspera, Bidens pilosa, Capparis sepiaria, Malvastrum coromandelianum* and unidentified Acanthaceae at two stages of growth (30 and 60 days after germination) (presented in summary Table 2).

Days after treatment	Treatments																Mean
	Control	*Achyranthes aspera*			*Bidens pilosa*			*Capparis sepiaria*			*Malvastrum coromandelianum*			Unidentified Acanthaceae			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination																
7	15 98±0 75	14 40±2 13	13 53±3 31	15 42±1 78	14 45±4 52	12 79±2 46	13 64±1 75	14 73±2 40	16 08±3 39	13 74±4 13	15 08±2 40	12 38±0 91	13 27±2 95	14 73±0 93	11 93±4 14	12 25±3 42	14 03
14	18 21±0 32	15 80±1 25	13 38±2 57	15 82±1 40	16 26±4 04	13 92±5 39	15 45±2 28	17 89±2 69	16 59±1 18	15 03±3 53	18 12±2 34	16 54±1 30	14 49±3 38	18 77±2 32	12 25±2 37	15 44±1 84	15 87
21	20 44±1 81	18 25±1 42	16 74±0 74	17 23±1 85	19 29±2 51	16 83±1 92	15 46±2 32	20 92±2 44	17 23±3 06	15 24±0 91	18 70±2 01	16 79±1 43	16 64±4 21	20 93±3 57	19 09±3 84	17 25±3 30	17 94
28	21 27±1 53	20 39±1 88	18 52±1 84	17 49±1 49	19 77±0 74	19 65±3 17	17 19±2 42	21 76±3 98	17 38±1 73	17 38±1 73	21 68±4 58	17 65±2 86	22 75±1 89	21 67±3 93	22 20±4 07	18 31±2 80	19 78
35	22 35±2 42	20 45±2 95	20 70±1 44	18 82±2 09	20 56±2 25	21 30±3 64	23 21±2 44	24 45±2 66	21 74±2 99	21 74±2 99	23 21±3 92	22 32±1 92	25 18±2 89	23 32±1 00	24 49±3 03	18 78±1 80	21 94
Mean	19 65	17 86	16 57	16 96	18 07	16 90	16 99	19 95	17 77	16 63	19 36	17 14	18 47	19 88	17 99	16 41	
LSD at 5%	T = 1 1	D = 1 90	I = NS														
LSD at 1%	T = 1 4	D = 2 49	I = NS														
	60 days after germination																
7	24 05±2 20	25 05±2 79	23 48±1 41	23 75±4 23	22 51±3 52	24 08±2 50	23 30±2 34	21 08±3 80	24 18±3 24	23 78±2 65	22 30±2 53	23 35±1 62	24 21±2 94	25 34±2 19	24 40±3 13	25 53±3 63	23 77
14	26 87±0 96	27 12±2 89	26 34±4 95	26 93±3 03	23 75±1 93	27 26±2 66	24 77±5 17	26 93±2 99	25 70±1 43	25 21±2 42	24 80±1 71	26 65±2 40	26 66±2 27	28 73±1 53	27 68±1 99	28 75±2 54	26 51
21	28 62±1 71	29 72±2 88	29 58±5 83	27 41±1 03	25 15±1 37	29 45±3 69	28 56±2 07	30 68±2 02	27 11±2 55	28 38±1 51	27 65±0 65	29 45±3 73	28 73±5 85	29 45±2 65	30 50±2 86	29 17±1 13	28 73
28	29 45±1 59	30 45±1 35	32 36±3 90	29 53±2 55	26 48±2 42	30 83±2 63	31 16±2 57	32 40±2 75	29 31±1 91	29 45±1 91	29 70±3 94	31 15±5 34	32 85±1 36	32 08±2 77	33 79±2 45	30 58±3 90	30 72
35	33 41±1 66	31 85±2 57	33 21±3 75	30 28±2 65	29 63±5 58	31 92±6 65	34 03±2 62	34 80±3 81	31 10±4 61	30 50±4 61	29 98±3 59	32 13±3 61	35 02±3 67	35 23±3 99	35 40±3 86	31 30±2 17	32 49
Mean	28 48	28 84	28 99	27 58	25 50	28 71	28 36	29 18	27 48	27 46	26 89	28 55	29 49	30 17	30 35	29 07	
LSD at 5%	T = 1 22	D = 2 19	I = NS														
LSD at 1%	Γ = 1 61	D = 2 88	I = NS														

Mean ± S.D

T = Treatments; D = Days after treatment, I = Interaction; NS = Non significant

Table 78. Leaf plant[-1] of selected invasive *Ruellia tuberosa* treated with varying root exudates of *Achyranthes aspera*, *Bidens pilosa*, *Capparis sepiaria*, *Malvastrum coromandelianum* and unidentified Acanthaceae at two stages of growth (30 and 60 days after germination) (presented in summary Table 2).

Days after treatment	Treatments																
	Control	*Achyranthes aspera*			*Bidens pilosa*			*Capparis sepiaria*			*Malvastrum coromandelianum*			Unidentified Acanthaceae			Mean
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination																
7	8 33±1 53	6 67±0 58	8 33±1 15	7 33±2 52	9 33±1 53	6 67±2 08	8 67±2 31	7 67±2 08	7 33±3 06	5 33±2 08	6 00±3 46	8 67±2 08	10 33±4 04	10 67±1 15	11 67±2 08	7 33±2 08	8 15
14	10 33±2 08	7 33±1 53	10 67±3 21	7 67±2 08	10 33±2 31	6 33±0 58	14 67±3 06	9 33±3 21	8 67±1 53	7 33±2 31	11 67±3 51	9 33±1 15	10 67±2 52	11 67±2 08	13 33±5 13	9 33±1 15	9 96
21	10 67±2 08	11 67±4 04	12 33±2 52	9 67±2 08	10 67±1 15	9 33±1 53	17 67±2 08	13 33±2 31	8 67±3 79	9 33±2 08	10 33±1 53	9 33±1 53	12 33±2 08	12 33±1 53	14 33±5 03	8 67±1 53	11 31
28	12 33±1 53	15 33±2 31	12 67±6 03	9 67±3 51	12 33±1 53	11 67±1 53	17 33±2 08	13 67±2 08	11 67±2 08	11 67±2 08	13 67±3 51	11 00±2 65	14 33±1 53	13 33±2 52	15 33±2 31	8 33±1 53	12 65
35	13 33±3 06	15 33±0 58	14 67±3 21	10 33±3 06	12 33±2 08	12 33±1 53	18 33±3 21	14 67±4 51	11 67±2 31	11 67±2 31	13 67±5 03	11 33±3 21	15 67±2 52	14 67±2 52	16 33±1 53	10 33±2 52	13 48
Mean	11 00	11 27	11 73	8 93	11 00	9 27	15 33	11 73	9 20	9 07	11 07	9 93	12 67	12 53	14 20	8 80	
LSD at 5%	T = 1 00	D = 1 80	I = NS														
LSD at 1%	T = 1 32	D = 2 36	I = NS														
	60 days after germination																
7	13 33±2 52	11 33±3 21	10 33±3 51	14 67±3 21	10 67±2 08	11 67±4 51	13 67±3 21	14 33±4 93	12 33±3 21	11 33±2 31	13 33±3 21	9 67±4 73	12 67±3 79	11 67±1 53	14 67±3 51	16 67±3 51	12 65
14	17 33±4 04	16 67±3 21	17 33±2 08	18 67±4 04	14 33±2 52	17 33±4 62	19 33±2 08	17 33±4 04	15 67±2 31	14 67±2 08	15 33±2 52	13 67±1 15	17 33±2 89	16 33±4 04	15 67±5 69	17 33±2 52	16 67
21	22 00±4 58	21 67±2 52	20 33±4 04	21 67±2 89	18 33±5 51	23 67±2 08	24 33±5 13	19 67±3 06	19 67±2 52	23 67±4 04	18 67±2 08	17 67±4 16	21 33±1 15	17 67±8 33	16 67±3 21	17 33±1 53	20 13
28	21 33±4 51	24 67±2 08	24 33±4 16	20 33±1 53	21 67±2 89	23 33±1 53	27 67±2 31	21 33±1 15	25 67±4 62	25 67±4 62	21 33±3 79	22 33±2 08	25 67±2 31	21 67±3 51	18 33±3 06	18 67±2 31	22 54
35	25 67±3 51	26 67±1 53	24 33±3 06	24 33±2 52	22 67±3 51	24 33±4 04	26 67±3 06	21 33±2 08	26 33±2 52	26 33±2 52	23 67±1 53	22 67±3 51	24 33±2 08	22 33±2 89	20 67±2 08	19 67±2 52	23 63
Mean	19 93	20 20	19 33	19 93	17 53	20 07	22 33	18 80	18 47	20 33	18 47	17 20	20 27	17 93	17 20	17 93	
LSD at 5%	T = 1 25	D = 2 23	I = NS														
LSD at 1%	T = 1 64	D = 2 94	I = NS														

Mean ± S D

T = Treatments, D = Days after treatment, I = Interaction, NS = Non significant

Table 79. Leaf area expansion (cm^2) of selected invasive *Ruellia tuberosa* treated with varying root exudates of *Achyranthes aspera*, *Bidens pilosa*, *Capparis sepiaria*, *Malvastrum coromandelianum* and unidentified Acanthaceae at two stages of growth (30 and 60 days from germination) (presented in summary Table 2).

Days after treatment	Control	*Achyranthes aspera*			*Bidens pilosa*			*Capparis sepiaria*			*Malvastrum coromoandelianum*			Unidentified Acanthaceae			Mean
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination																
7	3 17±1 18	3 25±1 45	4 75±2 16	3 52±1 61	2 45±0 24	3 35±0 56	4 05±1 52	3 21±0 88	3 11±1 60	3 35±1 47	4 45±1 97	5 08±1 79	4 15±2 06	3 15±1 25	2 95±0 57	4 25±1 60	3 64
14	9 75±1 77	7 50±1 94	8 45±2 04	10 25±0 49	9 75±3 25	10 60±4 02	11 75±2 86	10 75±2 88	9 78±3 16	8 35±2 80	7 31±3 25	10 94±2 27	11 21±1 35	8 75±4 25	9 38±1 83	10 45±0 96	9 69
21	13 25±1 97	15 35±1 85	12 77±2 63	15 50±3 32	16 75±3 83	14 75±2 61	17 25±3 02	18 15±3 33	14 35±3 83	15 35±2 71	14 38±1 71	13 45±3 39	12 35±2 66	15 95±2 25	16 50±4 38	12 25±3 71	14 90
28	17 50±3 28	21 75±4 64	20 25±1 57	18 50±1 17	21 50±1 77	22 75±2 04	23 50±2 18	20 50±2 51	21 75±2 26	20 75±2 26	18 21±3 46	17 31±2 07	19 45±2 34	15 23±0 52	17 91±3 72	18 75±2 32	19 73
35	23 83±1 58	24 70±0 80	22 00±4 02	22 52±2 40	21 10±3 90	23 50±2 38	24 78±5 29	21 75±3 11	22 50±2 61	25 50±2 61	23 25±3 48	22 75±7 85	24 75±1 81	25 60±4 42	22 75±5 51	20 18±3 27	23 22
Mean	13 50	14 51	13 64	14 06	14 31	14 99	16 27	14 87	14 30	14 66	13 52	13 91	14 38	13 74	13 90	13 18	
LSD at 5%	T = NS	D = 1 98	I = NS														
LSD at 1%	T = NS	D = 2 61	I = NS														
	60 days after germination																
7	2 08±0 47	4 75±1 08	2 45±0 56	3 08±0 70	4 35±0 99	2 16±0 49	2 08±0 47	3 98±0 90	3 49±0 79	2 75±0 63	3 54±0 80	3 78±0 86	2 68±0 61	4 78±1 09	5 16±1 17	2 76±0 63	3 37
14	9 97±2 27	11 17±2 54	9 78±2 22	9 74±2 21	12 59±2 86	7 35±1 67	9 25±2 10	11 79±2 68	8 34±1 90	10 65±2 42	8 45±1 92	11 05±2 51	9 38±2 13	8 45±1 92	12 36±2 81	10 75±2 44	10 07
21	18 20±4 14	16 95±3 85	15 85±3 60	20 75±4 72	21 24±4 83	18 95±4 31	14 21±3 23	17 36±3 95	20 50±4 66	14 50±3 30	12 68±2 88	18 76±4 26	12 75±2 90	18 65±4 24	16 85±3 83	16 38±3 72	17 16
28	23 05±5 24	20 25±4 60	19 78±4 50	21 05±4 78	23 50±5 34	22 62±5 14	20 15±4 58	18 23±4 14	19 08±4 34	19 08±4 34	21 31±4 84	23 45±5 33	19 25±4 38	20 25±4 60	17 05±3 88	21 95±4 99	20 73
35	24 35±5 53	24 48±5 56	24 56±5 58	21 27±4 83	24 38±5 54	23 75±5 40	25 49±5 79	20 64±4 69	26 75±6 08	26 75±6 08	23 36±5 31	25 75±5 85	22 98±5 22	25 39±5 77	20 46±4 65	24 38±5 54	23 67
Mean	15 53	15 52	14 48	15 18	17 21	14 97	14 24	14 40	14 77	14 75	13 87	16 56	13 41	15 50	14 38	15 24	
LSD at 5%	T = NS	D = 2 05	I = NS														
LSD at 1%	T = NS	D = 2 69	I = NS														

Mean ± S D.
T = Treatments, D = Days after treatment, I = Interaction, NS = Non significant

Table 80. Relative water content (%) of selected invasive *Ruellia tuberosa* treated with varying root exudates of *Achyranthes aspera*, *Bidens pilosa*, *Capparis sepiaria*, *Malvastrum coromandelianum* and unidentified Acanthaceae at two stages of growth (30 and 60 days after germination) (presented in summary Table 2).

Days after treatment	**Treatments**																**Mean**
	Control	***Achyranthes aspera***			***Bidens pilosa***			***Capparis sepiaria***			***Malvastrum coromandelianum***			**Unidentified Acanthaceae**			
		100ml	**200ml**	**400ml**	**100ml**	**200ml**	**400ml**	**100ml**	**200ml**	**400ml**	**100ml**	**200ml**	**400ml**	**100ml**	**200ml**	**400ml**	
	30 days after germination																
7	88 59±2 14	89 59±0 58	88 63±0 60	89 43±0 55	87 98±1 09	87 37±1 19	88 70±0 50	87 29±5 66	90 04±4 35	91 32±1 63	91 32±2 23	88 34±1 99	89 42±4 33	90 21±3 19	89 68±2 15	87 43±1 96	89 08
14	88 52±1 18	89 03±1 59	88 38±1 57	88 14±1 71	87 83±2 43	87 29±1 65	88 45±1 29	90 08±2 03	87 23±2 07	89 73±3 36	89 08±2 62	88 02±1 21	88 23±1 41	87 67±2 16	89 31±4 90	85 98±2 38	88 31
21	89 40±3 92	86 34±1 80	86 76±3 26	87 39±1 70	87 79±2 49	84 36±4 28	87 36±1 50	88 68±1 88	87 06±0 30	89 24±3 00	87 23±0 59	86 49±3 76	86 17±1 69	87 74±1 42	87 45±1 85	86 04±2 40	87 22
28	86 64±2 83	85 36±2 37	86 49±3 02	85 6±3 99	87 08±0 42	84 08±1 87	86 79±1 40	88 25±0 98	87 18±3 70	87 18±3 70	87 53±1 89	85 44±3 10	86 45±3 59	86 86±0 89	87 61±2 04	84 38±3 00	86 42
35	87 37±2 51	85 28±3 49	86 37±3 31	85 05±1 92	86 23±1 78	83 43±5 31	83 40±0 76	87 88±1 10	85 13±4 20	85 13±4 20	86 97±3 44	85 79±1 82	85 83±3 28	86 81±4 38	87 39±3 66	84 39±3 23	85 78
Mean	88 10	87 12	87 33	87 07	87 38	85 31	86 94	88 44	87 80	88 13	88 42	86 82	87 22	87 86	88 29	85 64	
LSD at 5%	T = NS	D = 1 89	I = NS														
LSD at 1%	T = NS	D = 2 48	I = NS														
	60 days after germination																
7	88 58±2 74	89 78±1 06	89 29±3 86	90 43±4 39	88 22±1 58	91 03±2 42	87 45±1 67	89 36±1 54	88 79±1 73	87 43±2 27	87 89±2 65	90 07±3 06	91 36±5 15	88 39±3 98	90 06±4 01	91 14±1 04	89 33
14	87 34±0 42	87 94±0 91	86 79±1 42	88 87±3 03	88 43±1 61	89 26±3 00	87 08±1 41	86 49±3 49	88 37±2 84	87 06±0 46	87 34±6 90	88 08±3 71	89 93±3 10	88 94±0 69	90 31±4 93	87 26±1 80	88 09
21	87 68±2 25	86 32±1 48	86 46±1 88	85 94±5 62	88 78±2 56	89 63±2 01	87 38±3 13	86 23±2 48	86 81±1 45	85 15±5 26	87 74±4 72	86 37±2 73	89 89±2 46	86 53±2 71	86 53±3 05	87 08±0 92	87 16
28	86 24±2 02	84 40±4 25	85 52±2 78	85 73±2 33	86 16±2 25	87 70±0 64	84 90±1 66	85 08±3 73	83 54±5 97	83 54±5 97	84 48±2 74	84 53±6 99	86 54±4 63	86 63±2 43	85 49±4 07	87 47±3 26	85 56
35	85 92±2 95	84 06±2 16	84 43±1 96	85 46±1 55	83 35±4 27	85 84±8 08	82 29±2 10	85 63±2 37	84 39±2 08	83 76±2 08	82 92±6 24	84 19±4 10	82 79±4 37	86 37±2 94	85 41±2 74	87 39±2 66	84 64
Mean	87 15	86 50	86 50	87 29	86 99	88 69	85 82	86 56	86 38	85 39	86 07	86 65	88 10	87 37	87 56	88 07	
LSD at 5%	T = NS	D = 2 36	I = NS														
LSD at 1%	T = NS	D = 3 11	I = NS														

Mean ± S D

T = Treatments, D = Days after treatment, I = Interaction, NS = Non significant

Table 81. Chlorophyll a (mg g^{-1} fresh weight) of selected invasive *Ruellia tuberosa* treated with varying root exudates of *Achyranthes aspera*, *Bidens pilosa*, *Capparis sepiaria*, *Malvastrum coromandelianum* and unidentified Acanthaceae at two stages of growth (30 and 60 days after germination) (presented in summary Table 2).

Days after treatment	Control	*Achyranthes aspera*			*Bidens pilosa*			*Capparis sepiaria*			*Malvastrum coromandelianum*			Unidentified Acanthaceae			Mean
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
								30 days after germination									
7	0 54±0 05	0 50±0 04	0 52±0 07	0 50±0 17	0 47±0 06	0 58±0 05	0 47±0 04	0 51±0 09	0 48±0 09	0 53±0 03	0 56±0 05	0 55±0 03	0 59±0 02	0 53±0 02	0 57±0 02	0 53±0 06	0 53
14	0 58±0 06	0 55±0 06	0 53±0 03	0 54±0 06	0 50±0 07	0 59±0 05	0 49±0 03	0 57±0 03	0 51±0 03	0 56±0 02	0 57±0 02	0 59±0 08	0 60±0 09	0 53±0 07	0 57±0 08	0 54±0 02	0 55
21	0 56±0 03	0 52±0 03	0 56±0 03	0 56±0 04	0 54±0 07	0 58±0 03	0 54±0 01	0 59±0 04	0 56±0 05	0 57±0 01	0 59±0 02	0 55±0 01	0 58±0 02	0 56±0 02	0 59±0 01	0 54±0 05	0 56
28	0 53±0 03	0 60±0 05	0 54±0 04	0 58±0 02	0 59±0 04	0 59±0 04	0 57±0 05	0 58±0 05	0 57±0 01	0 59±0 01	0 58±0 01	0 56±0 04	0 59±0 06	0 59±0 04	0 58±0 01	0 54±0 03	0 58
35	0 60±0 01	0 60±0 03	0 60±0 05	0 59±0 03	0 62±0 05	0 60±0 02	0 59±0 01	0 61±0 02	0 60±0 01	0 59±0 01	0 59±0 05	0 58±0 03	0 60±0 04	0 60±0 04	0 57±0 04	0 58±0 04	0 59
Mean	0 56	0 56	0 55	0 55	0 54	0 59	0 53	0 57	0 54	0 57	0 58	0 57	0 59	0 56	0 58	0 55	
LSD at 5%	T = 0 02	D = 0 03	I = NS														
LSD at 1%	T = 0 02	D = 0 04	I = NS														
								60 days after germination									
7	0 60±0 01	0 59±0 06	0 61±0 05	0 58±0 05	0 59±0 05	0 61±0 03	0 59±0 04	0 62±0 05	0 61±0 02	0 59±0 03	0 58±0 02	0 59±0 03	0 59±0 03	0 60±0 05	0 58±0 05	0 58±0 01	0 59
14	0 59±0 03	0 60±0 08	0 61±0 04	0 59±0 03	0 59±0 02	0 62±0 02	0 60±0 07	0 62±0 02	0 61±0 03	0 59±0 04	0 59±0 04	0 59±0 03	0 59±0 01	0 60±0 02	0 58±0 02	0 59±0 01	0 60
21	0 60±0 02	0 61±0 03	0 61±0 04	0 60±0 05	0 59±0 02	0 61±0 01	0 61±0 03	0 62±0 02	0 62±0 05	0 62±0 04	0 59±0 02	0 59±0 01	0 59±0 03	0 61±0 02	0 59±0 01	0 59±0 01	0 60
28	0 62±0 02	0 62±0 02	0 63±0 02	0 59±0 01	0 60±0 03	0 62±0 02	0 60±0 03	0 62±0 02	0 60±0 03	0 60±0 03	0 59±0 01	0 58±0 04	0 60±0 02	0 61±0 01	0 59±0 02	0 60±0 04	0 61
35	0 61±0 02	0 63±0 03	0 61±0 05	0 60±0 04	0 61±0 03	0 62±0 04	0 61±0 02	0 63±0 02	0 60±0 02	0 60±0 02	0 59±0 01	0 60±0 03	0 60±0 01	0 61±0 01	0 61±0 04	0 60±0 01	0 61
Mean	0 60	0 61	0 61	0 59	0 60	0 62	0 60	0 62	0 62	0 60	0 59	0 59	0 59	0 61	0 59	0 59	
LSD at 5%	T = 0 01	D = NS	I = NS														
LSD at 1%	T = 0 01	D = NS	I = NS														

Mean ± S D

T = Treatments, D = Days after treatment, I = Interaction, NS = Non significant

Table 82. Chlorophyll b (mg g^{-1} fresh weight) of selected invasive *Ruellia tuberosa* treated with varying root exudates of *Achyranthes aspera*, *Bidens pilosa*, *Capparis sepiaria*, *Malvastrum coromandelianum* and unidentified Acanthaceae at two stages of growth (30 and 60 days after germination) (presented in summary Table 2).

Days after treatment	Treatments																Mean
	Control	*Achyranthes aspera*			*Bidens pilosa*			*Capparis sepiaria*			*Malvastrum coromandelianum*			Unidentified Acanthaceae			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination																
7	0.36±0.03	0.32±0.02	0.35±0.05	0.36±0.03	0.36±0.04	0.37±0.02	0.35±0.02	0.36±0.02	0.37±0.02	0.36±0.04	0.37±0.02	0.37±0.08	0.37±0.02	0.36±0.05	0.37±0.04	0.36±0.04	0.36
14	0.39±0.01	0.35±0.02	0.36±0.02	0.37±0.01	0.37±0.00	0.38±0.01	0.35±0.03	0.37±0.01	0.37±0.02	0.36±0.01	0.37±0.02	0.37±0.04	0.37±0.02	0.37±0.02	0.37±0.02	0.37±0.01	0.37
21	0.41±0.03	0.36±0.02	0.38±0.05	0.38±0.01	0.38±0.03	0.39±0.06	0.36±0.01	0.37±0.05	0.38±0.04	0.37±0.02	0.38±0.02	0.38±0.05	0.38±0.04	0.36±0.03	0.38±0.01	0.37±0.03	0.38
28	0.38±0.02	0.36±0.04	0.37±0.01	0.38±0.02	0.38±0.02	0.39±0.05	0.37±0.03	0.37±0.01	0.37±0.02	0.37±0.02	0.38±0.01	0.39±0.02	0.38±0.03	0.38±0.01	0.38±0.01	0.37±0.02	0.38
35	0.39±0.02	0.37±0.05	0.34±0.06	0.39±0.02	0.38±0.01	0.39±0.03	0.37±0.02	0.37±0.03	0.38±0.03	0.37±0.03	0.39±0.01	0.39±0.03	0.37±0.01	0.38±0.03	0.38±0.02	0.38±0.03	0.38
Mean	0.39	0.35	0.36	0.38	0.37	0.39	0.36	0.37	0.37	0.37	0.38	0.38	0.37	0.37	0.38	0.37	
LSD at 5%	T = 0.01	D = 0.02	I = NS														
LSD at 1%	T = 0.02	D = 0.03	I = NS														
	60 days after germination																
7	0.33±0.03	0.36±0.02	0.38±0.03	0.39±0.06	0.38±0.01	0.39±0.04	0.36±0.01	0.36±0.03	0.38±0.03	0.36±0.03	0.38±0.01	0.39±0.02	0.37±0.04	0.38±0.02	0.38±0.02	0.38±0.02	0.37
14	0.39±0.02	0.38±0.01	0.37±0.02	0.40±0.03	0.38±0.02	0.40±0.02	0.38±0.03	0.38±0.05	0.38±0.01	0.37±0.03	0.38±0.03	0.39±0.04	0.38±0.04	0.38±0.01	0.39±0.04	0.38±0.01	0.38
21	0.38±0.04	0.39±0.05	0.38±0.02	0.39±0.07	0.39±0.06	0.39±0.03	0.38±0.01	0.37±0.03	0.39±0.01	0.37±0.01	0.39±0.01	0.39±0.03	0.38±0.01	0.39±0.02	0.39±0.01	0.37±0.02	0.38
28	0.39±0.02	0.39±0.03	0.38±0.02	0.40±0.02	0.39±0.02	0.40±0.01	0.38±0.01	0.38±0.02	0.39±0.02	0.37±0.02	0.38±0.01	0.38±0.04	0.38±0.02	0.39±0.02	0.39±0.03	0.36±0.01	0.38
35	0.41±0.01	0.39±0.02	0.38±0.03	0.41±0.03	0.39±0.02	0.40±0.04	0.39±0.02	0.38±0.02	0.39±0.01	0.38±0.01	0.39±0.00	0.40±0.04	0.39±0.01	0.39±0.04	0.39±0.01	0.38±0.02	0.39
Mean	0.38	0.38	0.38	0.40	0.39	0.39	0.38	0.37	0.39	0.37	0.38	0.39	0.38	0.39	0.39	0.37	
LSD at 5%	T = NS	D = 0.02	I = NS														
LSD at 1%	T = NS	D = 0.02	I = NS														

Mean ± S D

T = Treatments, D = Days after treatment, I = Interaction, NS = Non significant

Table 83. Total chlorophyll (mg g^{-1} fresh weight) of selected invasive *Ruellia tuberosa* treated with varying root exudates of *Achyranthes aspera*, *Bidens pilosa*, *Capparis sepiaria*, *Malvastrum coromandelianum* and unidentified Acanthaceae at two stages of growth (30 and 60 days after germination) (presented in summary Table 2).

Days after treatment	Treatments																Mean
	Control	*Achyranthes aspera*			*Bidens pilosa*			*Capparis sepiaria*			*Malvastrum coromandelianum*			Unidentified Acanthaceae			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination																
7	0 91±0 03	0 83±0 04	0 86±0 12	0 79±0 12	0 83±0 09	0 95±0 07	0 81±0 05	0 87±0 08	0 85±0 07	0 89±0 05	0 93±0 06	0 92±0 10	0 96±0 02	0 89±0 06	0 93±0 04	0 89±0 08	0 88
14	0 97±0 07	0 90±0 04	0 90±0 05	0 91±0 05	0 87±0 07	0 97±0 05	0 84±0 02	0 94±0 02	0 89±0 04	0 92±0 01	0 95±0 04	0 97±0 11	0 97±0 10	0 90±0 06	0 95±0 06	0 90±0 03	0 92
21	0 96±0 06	0 88±0 01	0 94±0 02	0 95±0 04	0 94±0 13	0 95±0 04	0 90±0 01	0 96±0 09	0 94±0 08	0 94±0 01	0 97±0 04	0 94±0 04	0 95±0 04	0 93±0 05	0 97±0 02	0 91±0 03	0 94
28	0 91±0 01	0 96±0 06	0 91±0 05	0 96±0 03	1 21±0 63	0 98±0 09	0 94±0 04	0 95±0 03	0 96±0 01	0 96±0 01	0 99±0 02	0 96±0 02	0 96±0 03	0 95±0 05	0 97±0 02	0 91±0 01	0 96
35	0 99±0 02	0 97±0 06	0 94±0 04	0 98±0 05	1 00±0 05	0 99±0 05	0 97±0 00	0 98±0 05	0 97±0 01	0 97±0 01	0 97±0 06	0 97±0 02	0 97±0 04	0 98±0 03	0 96±0 02	0 96±0 05	0 97
Mean	0 95	0 91	0 91	0 92	0 97	0 97	0 89	0 94	0 92	0 94	0 96	0 95	0 96	0 93	0 95	0 92	
LSD at 5%	T = NS	D = 0 06	I = NS														
LSD at 1%	T = NS	D = 0 08	I = NS														
	60 days after germination																
7	0 93±0 05	0 96±0 07	1 18±0 30	0 98±0 11	0 98±0 04	1 00±0 07	0 95±0 05	0 99±0 02	0 99±0 01	0 95±0 01	0 97±0 05	0 98±0 05	0 96±0 01	0 98±0 03	0 96±0 07	0 96±0 03	0 98
14	0 98±0 02	0 97±0 07	0 99±0 06	0 99±0 01	0 97±0 05	1 01±0 03	0 97±0 10	1 00±0 04	1 00±0 02	0 96±0 01	0 99±0 06	0 99±0 06	0 97±0 04	0 99±0 02	0 97±0 03	0 96±0 02	0 98
21	0 98±0 06	0 99±0 08	0 99±0 05	0 99±0 11	0 98±0 05	1 00±0 04	0 99±0 04	1 00±0 01	1 01±0 06	0 99±0 04	0 97±0 02	1 01±0 03	0 99±0 03	0 99±0 01	0 98±0 02	0 97±0 03	0 99
28	1 01±0 04	1 01±0 02	1 02±0 03	0 96±0 03	0 99±0 01	1 02±0 03	0 99±0 02	0 99±0 03	0 97±0 05	0 97±0 05	0 98±0 00	0 98±0 04	0 98±0 02	1 00±0 01	0 98±0 05	0 98±0 04	0 99
35	1 02±0 02	1 01±0 03	1 00±0 02	1 02±0 01	1 00±0 05	1 02±0 07	0 99±0 03	1 01±0 03	0 98±0 02	0 98±0 02	0 98±0 01	1 00±0 08	0 98±0 01	1 01±0 04	1 00±0 04	0 98±0 02	1 00
Mean	0 98	0 99	1 03	0 99	0 98	1 01	0 98	1 00	0 99	0 97	0 98	0 99	0 98	0 99	0 98	0 97	
LSD at 5%	T = NS	D = NS	I = NS														
LSD at 1%	T = NS	D = NS	I = NS														

Mean ± S D

T = Treatments, D = Days after treatment, I = Interaction, NS = Non significant

Table 84. Above ground biomass (g) of selected invasive *Ruellia tuberosa* treated with varying root exudates of *Achyranthes aspera, Bidens pilosa, Capparis sepiaria, Malvastrum coromandelianum* and unidentified Acanthaceae at two stages of growth (30 and 60 days after germination) (presented in summary Table 2).

Days after Germination	Treatments																LSD at	
	Control	*Achyranthes aspera*			*Bidens pilosa*			*Capparis sepiaria*			*Malvastrum coromandelianum*			Unidentified Acanthaceae				
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	5%	1%
30	2 35±0 59	2 21±0 21	2 78±0 26	2 53±0 42	2 53±1 26	2 01±0 46	2 65±0 23	2 24±0 80	2 18±0 48	2 04±0 47	2 43±0 19	2 68±0 33	2 21±0 41	2 26±0 78	2 32±0 69	2 36±0 20	NS	NS
60	4 70±1 34	3 98±0 59	4 05±0 33	3 86±0 26	4 52±0 89	4 30±0 56	4 19±0 81	4 63±0 31	4 83±0 07	4 45±0 38	4 35±1 13	4 79±0 47	4 86±1 00	4 38±0 83	4 54±0 24	4 72±0 44	NS	NS

Mean ± S.D.
NS = Non significant

Table 85. Stomata number of adaxial surface of selected invasive *Ruellia tuberosa* treated with varying root exudates of *Achyranthes aspera*, *Bidens pilosa*, *Capparis sepiaria*, *Malvastrum coromandelianum* and unidentified Acanthaceae at two stages of growth (30 and 60 days after germination) (presented in summary Table 2).

Days after treatment	Treatments																Mean
	Control	*Achyranthes aspera*			*Bidens pilosa*			*Capparis sepiaria*			*Malvastrum coromandelianum*			Unidentified Acanthaceae			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination																
7	3 90±2 03	3 90±1 71	4 10±1 39	3 90±1 71	3 67±1 80	3 57±2 01	3 90±1 06	3 90±1 82	4 10±3 27	4 03±2 52	4 00±1 76	3 90±0 72	3 43±1 21	3 67±0 85	3 87±1 50	4 00±2 72	3 87
14	4 30±1 00	4 43±1 21	4 23±2 50	4 23±1 36	4 43±0 81	4 20±3 65	4 23±2 25	4 20±1 15	4 13±2 14	4 23±0 81	4 33±0 91	4 33±1 19	4 20±2 15	4 33±0 91	4 33±1 88	4 30±1 28	4 28
21	4 90±0 72	4 77±0 50	4 90±2 31	4 53±1 37	4 43±1 03	4 57±0 81	4 43±1 03	4 33±1 46	4 10±1 85	4 10±1 59	4 43±0 98	4 23±0 81	4 53±1 08	4 63±1 83	4 37±1 15	4 77±2 93	4 50
28	3 43±1 03	4 10±1 59	3 43±1 21	3 00±0 70	3 10±0 72	3 43±1 21	3 23±0 81	3 53±1 08	3 23±1 37	3 23±1 37	3 23±1 36	3 67±1 80	3 43±1 25	3 10±1 93	2 77±1 36	3 43±0 51	3 34
35	4 70±1 00	4 90±1 71	3 90±1 31	4 10±2 31	4 37±1 53	4 23±3 01	4 23±0 92	4 63±2 17	4 33±2 57	4 33±2 57	4 20±1 01	4 53±3 33	4 57±1 50	4 73±1 34	4 47±2 54	4 80±1 15	4 45
Mean	4 25	4 42	4 11	3 95	4 00	4 00	4 01	4 12	4 00	3 99	4 04	4 13	4 03	4 09	3 96	4 26	
LSD at 5%	T = NS	D = 1 08	I = NS														
LSD at 1%	T = NS	D = 1 42	I = NS														
	60 days after germination																
7	4 23±1 86	4 23±1 36	4 10±1 06	4 10±1 82	4 33±2 33	4 43±2 38	4 23±3 11	4 26±1 86	4 23±1 50	4 10±2 31	4 13±1 50	4 00±1 18	4 00±0 30	4 23±1 57	4 10±2 59	4 20±0 85	4 18
14	5 57±1 03	5 00±2 17	5 57±2 01	5 53±1 08	4 90±1 93	4 77±3 32	5 00±1 87	5 47±3 03	5 23±3 23	5 33±0 85	5 57±1 69	5 43±2 80	5 23±1 66	6 57±2 68	5 67±1 42	5 47±2 80	5 39
21	6 43±2 80	6 20±1 91	6 40±1 66	6 33±2 81	6 23±3 23	6 47±2 04	6 20±1 82	6 10±1 71	5 77±1 86	6 20±2 15	6 23±3 23	6 13±0 51	6 43±2 50	6 33±1 46	6 43±2 38	6 40±0 95	6 27
28	6 90±2 31	7 00±2 00	7 03±0 58	6 77±2 16	6 67±1 74	7 23±3 01	7 20±2 82	6 67±1 35	6 43±1 96	6 57±1 96	6 77±1 50	6 43±3 38	6 97±1 70	7 07±3 59	7 00±1 18	7 20±0 85	6 87
35	5 10±2 31	5 23±3 11	6 00±1 87	6 50±0 62	5 23±2 36	5 57±3 38	5 43±2 50	5 10±1 85	4 90±2 43	4 90±2 43	4 90±2 55	5 00±1 76	5 10±2 85	5 20±2 76	4 90±1 71	4 90±3 65	5 25
Mean	5 65	5 53	5 82	5 85	5 47	5 69	5 61	5 52	5 31	5 42	5 52	5 40	5 55	5 88	5 62	5 63	
LSD at 5%	T = NS	D = 1 21	I = NS														
LSD at 1%	T = NS	D = 1 59	I = NS														

Mean ± S.D.

T = Treatments, D = Days after treatment, I = Interaction, NS = Non significant

Stomata number = per cm^2 area

Table 86. Stomatal index of adaxial surface of selected invasive *Ruellia tuberosa* treated with varying root exudates of *Achyranthes aspera*, *Bidens pilosa*, *Capparis sepiaria*, *Malvastrum coromandelianum* and unidentified Acanthaceae at two stages of growth (30 and 60 days after germination) (presented in summary Table 2).

Days after treatment	Treatments																Mean
	Control	*Achyranthes aspera*			*Bidens pilosa*			*Capparis sepiaria*			*Malvastrum coromandelianum*			Unidentified Acanthaceae			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination																
7	9 47±1 05	9 26±1 64	9 08±0 75	9 48±1 76	9 32±0 62	9 28±1 98	9 18±0 78	9 56±0 25	9 68±0 55	9 34±0 70	9 04±0 85	9 48±1 37	9 52±0 29	9 26±0 77	9 40±1 96	9 28±0 39	9 35
14	9 25±1 20	9 38±0 76	9 46±0 53	9 48±0 45	9 08±0 32	9 53±0 29	9 08±0 83	9 23±0 57	9 25±0 46	9 35±0 58	9 12±1 29	9 24±0 39	9 60±0 24	9 08±0 75	9 42±0 31	9 37±0 42	9 31
21	10 45±0 88	10 08±0 31	10 42±0 63	10 23±0 52	10 18±1 00	10 42±0 55	10 59±1 92	10 32±0 76	10 23±0 13	10 68±1 89	10 78±1 04	10 42±0 95	10 38±0 61	10 25±0 37	10 18±0 73	10 52±1 22	10 38
28	10 76±0 55	10 98±0 55	10 68±0 57	10 72±0 57	10 52±0 70	11 07±0 92	10 32±0 42	10 32±0 93	10 02±1 33	10 12±1 33	10 18±0 96	10 42±0 86	10 56±0 56	10 68±0 30	10 21±0 66	10 31±1 21	10 49
35	10 12±2 16	10 34±1 20	10 07±0 76	10 10±1 70	10 38±0 91	10 23±1 71	10 42±1 23	10 38±1 85	10 19±1 86	10 09±1 86	10 18±1 63	10 37±0 86	10 25±0 85	10 07±1 24	10 13±0 50	10 01±0 10	10 21
Mean	10 01	10 01	9 94	10 00	9 90	10 11	9 92	9 96	9 87	9 92	9 86	9 99	10 06	9 87	9 87	9 90	
LSD at 5%	T = NS	D = 0 71	I = NS														
LSD at 1%	T = NS	D = 0 94	I = NS														
	60 days after germination																
7	12 07±2 70	12 09±0 99	11 98±0 54	12 13±0 84	12 12±0 88	12 23±1 21	11 92±0 80	11 87±0 46	12 23±0 19	12 13±0 13	11 98±1 10	11 89±0 64	12 08±0 81	12 19±0 26	12 08±0 22	12 04±0 14	12 06
14	11 78±1 21	11 98±1 74	11 43±0 23	11 76±1 51	12 08±0 55	12 02±0 86	11 98±0 12	11 34±0 34	11 68±0 45	11 94±0 98	11 85±0 71	11 73±0 15	11 90±1 33	11 68±0 86	11 43±1 00	11 52±1 38	11 76
21	11 56±1 12	11 46±0 69	11 38±0 36	11 62±0 62	11 50±0 42	11 49±0 50	11 68±0 64	11 42±0 67	11 08±0 18	11 35±0 25	11 46±0 42	11 87±1 40	11 79±1 11	11 62±0 29	11 42±0 53	11 51±0 80	11 51
28	11 30±1 79	11 22±0 52	11 08±0 19	11 43±2 13	11 32±0 71	11 49±0 82	11 56±0 57	11 21±1 27	11 45±0 65	11 53±0 65	11 31±0 48	11 42±0 85	11 62±0 24	11 23±0 14	11 17±0 32	11 36±0 63	11 36
35	11 44±1 67	11 30±0 25	11 29±0 20	11 56±0 36	11 40±0 39	11 68±0 17	11 18±0 47	11 09±1 27	11 14±0 48	11 39±0 48	11 29±1 04	11 32±0 20	11 43±0 13	11 59±0 17	11 26±0 51	11 67±1 15	11 38
Mean	11 63	11 61	11 43	11 70	11 68	11 78	11 66	11 39	11 52	11 67	11 58	11 65	11 76	11 66	11 47	11 62	
LSD at 5%	T = NS	D = 0 61	I = NS														
LSD at 1%	T = NS	D = 0 81	I = NS														

Mean ± S D

T = Treatments, D = Days after treatment, I = Interaction, NS = Non significant

Table 87. Stomata number of abaxial surface of selected invasive *Ruellia tuberosa* treated with varying root exudates of *Achyranthes aspera*, *Bidens pilosa*, *Capparis sepiaria*, *Malvastrum coromandelianum* and unidentified Acanthaceae at two stages of growth (30 and 60 days after germination) (presented in summary Table 2).

Days after treatment	Treatments																Mean
	Control	*Achyranthes aspera*			*Bidens pilosa*			*Capparis sepiaria*			*Malvastrum coromandelianum*			Unidentified Acanthaceae			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination																
7	28 43±4 23	28 10±5 41	28 13±8 24	28 43±3 67	28 33±1 46	28 57±6 41	28 03±6 66	27 87±4 84	28 09±2 41	28 33±7 37	28 63±7 64	28 47±9 58	28 10±4 01	28 23±0 50	28 20±4 42	28 33±1 42	28 27
14	30 90±3 81	31 33±4 51	31 23±4 08	30 87±3 96	30 77±9 68	31 23±3 01	30 47±8 08	30 77±5 08	31 23±10 8	31 10±12 1	31 23±9 22	31 10±10 1	29 90±6 01	30 90±1 06	30 67±3 15	31 10±4 75	30 93
21	26 97±3 51	27 20±2 48	27 10±2 31	27 00±2 36	26 80±7 88	26 57±4 63	27 10±3 00	27 00±3 86	27 23±1 86	27 13±2 68	26 77±2 84	26 93±2 80	27 00±2 36	26 80±1 91	27 00±0 89	26 87±4 83	26 97
28	24 43±2 58	24 10±7 66	24 57±3 78	24 13±2 50	24 43±2 42	24 37±3 21	24 67±3 69	24 33±4 92	24 10±3 54	23 90±3 54	24 20±3 64	24 57±2 01	24 10±1 31	24 20±3 27	24 33±4 23	25 67±2 94	24 38
35	22 90±1 31	22 57±5 14	23 00±3 70	22 90±6 97	22 77±3 83	22 90±4 66	22 90±0 85	23 13±5 75	23 10±2 00	23 00±2 00	23 10±2 99	23 10±1 93	22 90±2 48	22 77±2 25	22 80±4 29	22 90±1 85	22 92
Mean	26 73	26 66	26 81	26 67	26 62	26 73	26 63	26 62	26 75	26 69	26 79	26 83	26 40	26 58	26 60	26 97	
LSD at 5%	T = NS	D = 3 41	I = NS														
LSD at 1%	T = NS	D = 4 48	I = NS														
	60 days after germination																
7	23 90±4 57	24 10±5 60	24 03±4 16	24 43±3 44	23 43±6 09	24 10±6 13	24 10±2 88	24 33±3 55	24 23±2 66	24 20±2 59	25 03±3 91	24 10±2 88	24 37±3 51	24 00±5 46	24 00±2 70	24 13±4 12	24 16
14	26 63±2 52	26 90±3 57	27 00±2 00	26 20±4 00	26 33±2 06	26 67±2 17	26 77±2 25	26 00±2 72	26 33±4 16	26 47±5 64	26 43±2 20	26 77±2 54	26 43±5 39	26 43±2 23	26 53±4 02	26 67±4 10	26 54
21	28 90±2 78	29 23±2 73	29 10±5 30	28 90±1 93	28 67±2 33	28 80±7 57	29 10±2 08	28 77±5 71	29 10±2 71	28 90±4 55	28 90±4 91	28 73±0 67	28 57±2 01	28 87±3 39	28 90±4 62	28 77±3 11	28 89
28	20 77±1 86	21 33±3 50	21 00±2 88	20 90±4 53	20 80±3 73	20 67±2 33	21 00±2 17	21 13±1 40	20 67±4 00	20 80±4 00	21 20±1 82	21 13±2 50	20 80±5 11	20 67±3 69	20 97±3 59	20 67±4 80	20 91
35	22 10±1 59	22 33±2 87	22 47±5 21	22 10±3 54	22 23±6 44	22 67±3 39	22 13±3 50	22 00±4 58	22 10±9 33	22 33±9 33	22 33±2 81	21 90±5 70	20 13±4 05	20 10±4 85	20 23±4 88	20 13±1 50	21 71
Mean	24 46	24 78	24 72	24 51	24 29	24 58	24 62	24 45	24 49	24 54	24 78	24 53	24 06	24 01	24 13	24 07	
LSD at 5%	T = NS	D = 2 57	I = NS														
LSD at 1%	T = NS	D = 3 38	I = NS														

Mean ± S D
T = Treatments, D = Days after treatment, I = Interaction, NS = Non significant
Stomata number = per cm^2 area

Table 88. Stomatal index of abaxial surface of selected invasive *Ruellia tuberosa* treated with varying root exudates of *Achyranthes aspera*, *Bidens pilosa*, *Capparis sepiaria*, *Malvastrum coromandelianum* and unidentified Acanthaceae at two stages of growth (30 and 60 days after germination) (presented in summary Table 2).

Days after treatment	Treatments																Mean
	Control	*Achyranthes aspera*			*Bidens pilosa*			*Capparis sepiaria*			*Malvastrum coromandelianum*			Unidentified Acanthaceae			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination																
7	35 70±3 06	35 98±2 03	35 72±0 41	35 62±0 31	35 43±0 86	35 53±1 12	35 64±0 32	35 98±0 25	35 69±0 42	35 32±4 94	35 42±0 94	35 84±10 9	35 93±1 70	35 38±2 85	35 26±3 27	35 69±2 43	35 63
14	37 06±1 72	37 43±1 32	37 08±1 54	36 98±0 62	37 12±3 00	37 23±0 98	37 08±2 69	37 13±1 62	37 34±1 01	37 21±2 00	36 90±2 18	37 14±8 67	37 28±0 70	37 01±0 42	37 45±0 38	37 39±1 45	37 18
21	36 77±2 34	36 43±1 45	36 55±0 24	37 84±0 43	36 62±1 12	37 34±1 23	36 75±0 99	36 81±3 34	36 95±0 51	36 42±0 88	37 34±2 03	36 54±3 99	36 68±2 35	36 74±2 02	36 84±0 89	36 73±1 07	36 83
28	34 82±1 50	37 33±0 34	35 36±0 20	34 95±0 33	38 20±0 29	38 02±0 91	36 67±0 65	37 15±0 32	35 72±1 84	35 72±1 84	38 18±0 20	34 50±5 02	38 34±0 51	38 62±0 09	36 72±1 09	35 51±1 50	36 75
35	37 21±3 00	37 19±0 80	37 68±0 29	37 42±0 62	36 89±0 49	37 31±2 45	37 48±0 57	37 28±1 90	37 38±2 32	37 38±2 32	37 42±1 67	37 39±1 44	37 42±1 76	37 04±0 40	37 36±1 38	37 16±2 90	37 30
Mean	36 31	36 87	36 48	36 56	36 85	37 09	36 72	36 87	37 00	36 41	37 05	36 28	37 13	36 96	36 73	36 50	
LSD at 5%	T = NS	D = 1 69	I = NS														
LSD at 1%	T = NS	D = 2 22	I = NS														
	60 days after germination																
7	28 48±4 33	28 68±1 91	28 42±2 23	30 08±0 29	28 63±1 91	28 78±1 05	28 24±0 41	28 69±0 59	28 53±0 84	28 04±0 73	28 31±0 61	28 59±2 41	28 35±0 85	28 21±2 09	28 68±0 59	28 39±1 82	28 57
14	31 22±1 66	30 45±1 21	31 08±2 34	30 49±1 59	30 68±1 22	30 53±0 39	31 12±2 14	28 71±5 28	30 61±3 97	30 83±5 02	31 20±2 01	29 98±2 32	29 83±9 16	30 76±3 22	29 78±2 98	30 53±2 83	30 49
21	29 43±1 18	30 25±0 43	30 45±2 64	32 51±2 24	30 41±4 94	31 78±5 92	31 45±2 78	30 68±1 10	31 79±1 58	29 89±0 80	29 78±2 65	29 84±4 81	28 36±1 24	30 68±2 76	30 41±3 28	30 93±1 81	30 54
28	32 11±2 63	31 68±0 35	32 24±1 45	30 28±4 56	31 73±4 65	35 84±4 63	33 62±3 28	33 21±5 12	32 52±6 19	32 52±6 19	29 38±1 18	31 41±4 34	31 98±5 43	32 50±6 21	30 68±7 29	31 78±2 45	32 14
35	33 50±1 72	33 83±0 22	33 45±0 63	33 21±0 51	33 71±1 87	33 45±0 89	34 58±3 77	34 36±4 02	33 29±3 09	33 29±3 09	33 42±1 93	33 39±2 22	33 47±1 63	33 53±4 60	33 68±3 36	33 52±3 12	33 67
Mean	30 95	30 98	31 13	31 31	31 03	32 08	31 80	31 13	31 70	30 91	30 42	30 64	30 40	31 14	30 65	31 03	
LSD at 5%	T = NS	D = 2 32	I = NS														
LSD at 1%	T = NS	D = 3 05	I = NS														

Mean ± S D

T = Treatments, D = Days after treatment, I = Interaction, NS = Non significant

Table 89. Proportion of leaf tissues of selected invasive *Ruellia tuberosa* treated with varying root exudates of *Achyranthes aspera*, *Bidens pilosa*, *Capparis sepiaria*, *Malvastrum coromandelianum* and unidentified Acanthāceae at two stages of growth (30 and 60 days from germination) (presented in summary Table 2).

Leaf tissues	Control	Treatments															LSD at	
		Achyranthes aspera			*Bidens pilosa*			*Capparis sepiaria*			*Malvastrum coromandelianum*			Unidentified Acanthaceae				
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	5%	1%
30 days after germination																		
Dermal system	1199.4±208.9	1123.2±128.5	1069.6±94.7	1086.4±168.1	1127.9±35.8	1086.2±217.9	1125.4±78.0	1068.4±152.0	1201.6±154.1	1082.2±119.0	1117.4±133.3	1054.2±149.1	1197.4±207.2	1056.3±130.4	1084.5±83.1	1137.7±144.4	NS	NS
Palisade parenchyma	1876.2±73.3	1908.5±126.3	1903.5±158.5	2006.5±307.3	1879.8±68.5	1925.8±232.4	1836.7±215.8	1905.4±95.6	1831.2±26.0	1872.2±66.2	1895.6±128.2	1905.4±249.5	1925.3±224.6	1892.2±72.0	1952.2±395.8	1883.7±235.6	NS	NS
Spongy parenchyma	1995.2±114.7	2013.4±104.7	1895.2±117.3	1954.6±123.5	1906.4±63.1	1934.7±66.5	1975.3±264.5	2005.2±164.3	2015.8±221.1	1984.6±435.8	1905.0±110.8	2015.4±244.6	1964.4±344.6	1997.6±259.2	2004.5±143.8	1985.7±156.0	NS	NS
Vascular area	55.5±8.9	50.3±2.2	47.5±9.5	53.7±5.9	51.6±8.0	48.5±5.7	50.1±2.7	52.7±2.0	54.4±9.7	50.2±6.5	47.4±3.9	48.8±4.1	51.1±13.7	53.2±9.5	53.5±11.0	50.2±4.9	NS	NS
Total leaf tissue area	5126.3±378.1	5095.4±317.0	4915.8±61.4	5101.2±315.1	4965.7±60.8	4995.2±224.2	4987.5±233.7	5031.7±185.1	5103.0±264.4	4989.2±121.3	4965.0±31.0	5023.8±135.1	5138.2±533.1	4999.3±216.7	5094.7±468.7	5057.3±39.3	NS	NS
60 days after germination																		
Dermal system	1089.3±121.0	1073.4±119.3	1121.1±124.6	1086.9±120.8	1107.4±123.0	1098.5±122.1	1103.5±122.6	1096.7±121.9	1105.7±122.9	1113.5±123.7	1093.2±121.5	1108.3±123.1	1105.6±122.8	1095.4±121.7	1102.3±122.5	1116.5±124.1	NS	NS
Palisade parenchyma	1819.1±202.1	1826.8±203.0	1807.4±200.8	1838.6±204.3	1808.9±201.0	1822.7±202.5	1841.8±204.6	1812.7±201.4	1786.9±198.5	1809.8±201.1	1834.2±203.8	1854.8±206.1	1823.6±202.6	1815.2±201.7	1831.9±203.6	1805.9±200.7	NS	NS
Spongy parenchyma	1925.2±213.9	1956.1±217.3	1937.6±215.3	1920.2±213.4	1961.5±217.9	1977.9±219.8	1905.2±211.7	1950.3±216.7	1949.5±216.6	1945.1±216.1	1955.7±217.3	1879.8±208.9	1907.5±211.9	1928.8±214.3	1930.8±214.5	1935.4±215.0	NS	NS
Vascular area	49.9±5.5	48.9±5.4	50.4±5.6	48.8±5.4	49.5±5.5	49.4±5.5	48.6±5.4	49.7±5.5	50.4±5.6	53.9±6.0	49.3±5.5	49.2±5.5	49.5±5.5	50.2±5.6	49.1±5.5	49.6±5.5	NS	NS
Total leaf tissue area	4883.5±542.6	4905.2±545.0	4916.5±546.3	4894.5±543.8	4927.3±547.5	4948.5±548.8	4899.1±544.4	4909.4±545.5	4892.5±543.6	4922.3±546.5	4932.4±548.0	4892.1±543.6	4886.1±542.8	4889.6±543.3	4914.1±546.0	4907.4±545.3	NS	NS

Mean ± S D (values show area of each tissue system in μm^2 in avertical section of leaf)
NS = Non significant

Table 90. Floral buds plant^{-1} of selected invasive *Ruellia tuberosa* treated with varying root exudates of *Achyranthes aspera*, *Bidens pilosa*, *Capparis sepiaria*, *Malvastrum coromandelianum* and unidentified Acanthaceae at two stages of growth (30 and 60 days after germination) (presented in summary Table 2).

Days after treatment	Treatments																Mean
	Control	*Achyranthes aspera*			*Bidens pilosa*			*Capparis sepiaria*			*Malvastrum coromandelianum*			Unidentified Acanthaceae			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination																
7	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00
14	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00
21	1 33±1 15	1 00±1 00	1 33±1 53	1 67±1 53	1 33±0 58	0 67±1 15	0 33±0 58	1 00±0 00	1 33±0 58	1 33±1 15	1 67±1 53	1 00±1 00	1 00±1 73	1 33±0 58	1 67±1 15	1 00±1 73	1 19
28	3 67±1 53	3 33±1 53	2 67±0 58	2 67±2 52	2 33±1 53	3 33±0 58	3 67±1 53	2 33±1 53	3 33±1 15	3 33±1 15	3 67±2 52	3 67±1 15	3 33±2 31	3 33±2 08	2 67±1 15	3 33±2 08	3 10
35	3 33±1 53	3 67±0 58	3 33±0 58	2 67±1 53	3 67±1 15	3 33±1 15	3 67±3 06	3 33±0 58	3 33±1 53	3 33±1 53	2 67±2 08	3 33±1 53	3 33±1 15	3 33±0 58	2 67±1 53	3 33±1 53	3 29
Mean	1 67	1 60	1 47	1 40	1 47	1 47	1 53	1 33	1 47	1 60	1 60	1 60	1 53	1 60	1 40	1 53	
LSD at 5%	T = NS	D = 0 77	I = NS														
LSD at 1%	T = NS	D = 1 02	I = NS														
	60 days after germination																
7	4 33±3 21	4 33±2 31	3 33±1 53	3 67±0 58	3 67±1 53	3 67±2 89	4 33±2 08	4 33±1 53	4 33±2 52	3 67±1 53	3 67±1 15	4 67±1 53	4 33±3 21	4 33±1 15	4 33±1 53	4 33±2 31	4 08
14	4 67±0 58	3 67±1 15	4 33±1 15	3 33±3 21	3 67±2 08	4 33±0 58	4 33±3 21	4 33±2 52	4 33±2 52	3 67±0 58	3 33±1 53	4 33±1 15	4 67±2 08	4 67±2 89	4 67±1 53	5 33±2 08	4 23
21	5 33±2 08	4 33±0 58	3 67±2 08	4 33±1 15	4 67±2 52	4 67±1 53	4 67±2 52	4 33±2 08	5 33±3 06	5 33±2 52	4 67±0 58	4 67±2 89	4 33±1 53	5 33±2 31	4 67±2 52	5 33±0 58	4 73
28	5 33±1 53	5 67±2 08	6 00±1 00	5 33±1 15	5 33±1 15	6 33±1 53	4 67±1 53	4 67±0 58	5 33±0 58	5 67±0 58	5 33±2 52	5 33±1 15	6 33±3 79	6 33±0 58	5 67±1 53	5 33±3 06	5 52
35	6 33±2 52	5 67±2 52	6 33±1 53	6 33±2 08	6 33±1 15	6 33±2 08	6 33±2 31	5 67±1 53	5 67±3 79	6 33±3 79	5 67±2 08	6 33±3 06	5 67±1 15	6 33±1 53	6 33±3 21	6 33±2 08	6 15
Mean	5 20	4 73	4 73	4 60	4 73	5 07	4 87	4 67	5 00	4 93	4 53	5 07	5 07	5 40	5 13	5 33	
LSD at 5%	T = NS	D = 1 44	I = NS														
LSD at 1%	T = NS	D = 1 89	I = NS														

Mean ± S D

T = Treatments, D = Days after treatment, I = Interaction, NS = Non significant

Table 91. Flower plant^{-1} of selected invasive *Ruellia tuberosa* treated with varying root exudates of *Achyranthes aspera, Bidens pilosa, Capparis sepiaria, Malvastrum coromandelianum* and unidentified Acanthaceae at two stages of growth (30 and 60 days from germination) (presented in summary Table 2).

Days after treatment	Treatments																Mean
	Control	*Achyranthes aspera*			*Bidens pilosa*			*Capparis sepiaria*			*Malvastrum coromoandelianum*			Unidentified Acanthaceae			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination																
7	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00
14	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00
21	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00
28	2 67±0 89	0 67±0 22	1 67±0 56	2 00±0 67	2 33±0 78	1 67±0 56	1 33±0 44	2 67±0 89	2 33±0 78	2 33±0 78	1 67±0 56	1 33±0 44	1 33±0 44	0 67±0 22	0 67±0 22	1 67±0 56	1 69
35	3 33±1 11	4 33±1 44	3 67±1 22	4 33±1 44	3 67±1 22	3 33±1 11	2 67±0 89	3 33±1 11	3 67±1 22	3 67±1 22	3 33±1 11	3 33±1 11	2 67±0 89	2 67±0 89	3 33±1 11	3 33±1 11	3 42
Mean	1 20	1 00	1 07	1 27	1 20	1 00	0 80	1 20	1 20	1 20	1 00	0 93	0 80	0 67	0 80	1 00	
LSD at 5%	*T = NS*	*D = 0 39*	*I = NS*														
LSD at 1%	T = NS	D = 0 52	I = NS														
	60 days after germination																
7	1 67±0 83	2 33±1 17	1 67±0 83	1 33±0 67	2 33±1 17	1 67±0 83	1 67±0 83	1 33±0 67	1 67±0 83	1 33±0 67	1 67±0 83	2 33±1 17	1 67±0 83	2 33±1 17	1 67±0 83	1 33±0 67	1 75
14	2 33±1 17	2 67±1 33	3 33±1 67	3 67±1 83	3 33±1 67	3 67±1 83	2 67±1 33	3 67±1 83	3 33±1 67	3 67±1 83	3 33±1 67	2 67±1 33	3 33±1 67	3 33±1 67	2 33±1 17	3 33±1 67	3 17
21	2 33±1 17	3 67±1 83	2 33±1 17	2 67±1 33	2 67±1 33	3 33±1 67	1 67±0 83	2 33±1 17	2 67±1 33	2 67±1 33	2 33±1 17	2 33±1 17	3 67±1 83	1 33±0 67	2 33±1 17	2 33±1 17	2 54
28	2 67±1 33	2 33±1 17	2 33±1 17	2 67±1 33	2 33±1 17	1 67±0 84	2 33±1 17	2 67±1 33	2 67±1 34	2 67±1 34	1 67±0 84	2 67±1 34	2 67±1 34	2 67±1 33	2 33±1 17	2 67±1 33	2 48
35	3 33±1 67	2 67±1 34	2 67±1 34	3 33±1 67	2 67±1 34	1 67±0 84	2 67±1 34	3 33±1 67	3 33±1 67	3 33±1 67	2 67±1 33	2 67±1 33	2 33±1 17	2 00±1 00	2 67±1 33	2 67±1 33	2 71
Mean	2 47	2 73	2 47	2 73	2 67	2 40	2 20	2 67	2 73	2 73	2 33	2 53	2 73	2 33	2 27	2 47	
LSD at 5%	T = NS	D = 0 56	I = NS														
LSD at 1%	T - NS	D = 0 73	I = NS														

Mean ± S D

T = Treatments, D – Days after treatment, I = Interaction, NS = Non significant

Table 92. Fruit plant^{-1} of selected invasive *Ruellia tuberosa* treated with varying root exudates of *Achyranthes aspera*, *Bidens pilosa*, *Capparis sepiaria*, *Malvastrum coromandelianum* and unidentified Acanthaceae at two stages of growth (30 and 60 days from germination) (presented in summary Table 2).

Days after treatment	Treatments																Mean
	Control	*Achyranthes aspera*			*Bidens pilosa*			*Capparis sepiaria*			*Malvastrum coromoandelianum*			Unidentified Acanthaceae			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
	30 days after germination																
7	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00
14	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00
21	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00
28	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00±0 00	0 00
35	1 67±0 81	0 67±0 33	0 33±0 16	2 33±1 14	1 67±0 81	1 33±0 65	1 33±0 65	1 67±0 81	1 33±0 65	1 33±0 65	1 67±0 81	1 67±0 81	2 33±1 14	2 33±1 14	2 33±1 14	1 67±0 81	1 63
Mean	0 33	0 13	0 07	0 47	0 33	0 27	0 27	0 33	0 33	0 27	0 33	0 33	0 47	0 47	0 47	0 33	
LSD at 5%	T = NS	D = 0 26	I = NS														
LSD at 1%	T = NS	D = 0 35	I = NS														
	60 days after germination																
7	2 00±1 00	2 67±1 15	1 33±0 58	2 33±0 58	2 33±1 53	1 67±0 58	1 33±0 58	1 67±1 15	1 67±1 15	1 33±0 58	1 00±0 00	1 67±1 15	2 33±0 58	1 33±0 58	2 67±2 08	1 67±0 58	1 81
14	2 33±1 15	2 33±0 58	2 00±1 00	2 67±0 58	3 00±1 73	2 00±1 73	2 67±2 08	2 33±1 15	2 67±1 15	2 33±0 58	1 67±0 58	2 33±1 53	2 67±0 58	3 33±0 58	3 33±1 53	2 33±0 58	2 50
21	2 33±1 53	2 67±1 15	2 67±2 08	3 33±3 21	3 33±1 53	2 67±2 08	3 67±0 58	3 67±1 53	3 33±0 58	3 33±1 53	2 67±0 58	2 33±1 53	2 00±1 00	2 33±0 58	2 67±1 15	3 33±1 53	2 90
28	3 33±1 15	3 67±1 15	3 33±0 58	3 00±2 65	2 67±1 53	2 33±0 58	2 33±1 15	3 33±2 52	3 67±1 15	3 67±1 15	2 33±2 08	2 67±1 15	2 00±1 73	2 67±2 08	1 33±2 52	2 33±0 58	2 79
35	2 67±2 08	3 33±1 15	2 67±1 15	2 00±1 00	2 67±0 58	3 33±2 52	3 33±2 08	2 00±1 00	2 67±1 15	2 67±1 15	1 67±2 08	2 33±1 15	1 33±1 53	1 33±2 52	1 67±1 53	3 33±2 08	2 44
Mean	2 53	2 93	2 40	2 67	2 80	2 40	2 67	2 60	2 80	2 67	1 87	2 27	2 07	2 20	2 33	2 60	
LSD at 5%	T = NS	D = 0 89	I = NS														
LSD at 1%	T = NS	D = 1 17	I = NS														

Mean ± S D

T = Treatments, D = Days after treatment, I = Interaction, NS = Non significant

Table 93. Seed output plant^{-1} of selected invasive *Ruellia tuberosa* treated with varying root exudates of *Achyranthes aspera*, *Bidens pilosa*, *Capparis sepiaria*, *Malvastrum coromandelianum* and unidentified Acanthaceae at two stages of growth (30 and 60 days from germination) (presented in summary Table 2).

Days after treatment	Treatments																Mean
	Control	*Achyranthes aspera*			*Bidens pilosa*			*Capparis sepiaria*			*Malvastrum coromoandelianum*			Unidentified Acanthaceae			
		100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	100ml	200ml	400ml	
7	76 3±8 0	73 3±5 1	83 7±11 5	77 7±8 0	75 3±21 5	72 0±23 0	78 3±9 5	78 3±14 0	75 3±8 6	79 3±10 0	84 3±9 6	82 7±15 6	85 3±5 0	77 0±12 3	74 7±11 2	71 3±18 1	77 8
14	82 7±9 7	79 3±15 0	94 3±10 1	86 7±9 1	92 3±11 0	87 7±6 0	92 3±15 8	76 7±15 7	79 3±17 6	85 3±16 0	92 7±19 6	77 3±7 8	76 3±23 5	84 0±7 5	76 7±17 1	79 7±16 5	84 0
21	88 7±9 1	96 7±11 5	99 3±6 0	96 0±8 9	90 0±15 7	93 3±6 0	99 7±8 7	85 3±9 1	89 7±18 5	92 3±15 0	83 3±9 1	80 7±16 8	92 0±22 1	86 3±24 6	92 7±9 7	89 3±11 8	91 0
28	93 7±9 1	101 0±19 5	95 0±4 6	103 3±17 0	102 7±10 2	87 3±12 6	103 0±19 1	93 7±16 8	90 3±10 8	90 3±10 8	100 7±13 3	95 3±10 0	90 3±11 7	95 7±31 9	90 3±16 6	85 0±16 0	95 3
35	102 3±5 0	97 3±9 5	107 7±22 6	105 7±13 1	102 3±29 3	99 7±29 4	93 3±18 0	101 0±18 5	99 7±32 5	99 7±32 5	105 3±11 6	101 3±21 2	104 7±40 1	97 7±17 9	103 3±17 6	98 7±14 3	101 5
Mean	88 7	89 5	96 0	93 9	92 5	88 0	93 3	87 0	89 1	89 4	93 3	87 5	89 7	88 1	87 5	84 8	
LSD at 5%	T = NS	D = 11 6	I = NS														
LSD at 1%	T = NS	D = 15 3	I = NS														

Mean ± S.D.

T = Treatments; D = Days after treatment; I = Interaction, NS = Non significant